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GEOLOGY OF OIL AND GAS FIELDS OF WESTERN KENTUCKY[1]

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ABSTRACT

Oil and gas are found in western Kentucky chiefly in the Silurian and Devonian limestones and dolomites close below the Chattanooga shale, and in the sandstones of the Chester series. Most of the oil and gas is produced from the flanks of a large structural basin. The strata beneath the Chattanooga shale dip toward the basin a little more steeply than the overlying beds, and this has had an important influence on the production from beneath the shale. Accumulation in western Kentucky is partly in lenticular reservoirs off structure, and partly on anticlines in the more persistent horizons. Much of the oil and gas in the Silurian and Devonian was probably derived from the bituminous Chattanooga shale. The oil and gas in the Chester evidently originated close to the producing horizons, and the vertical movement was probably less than 200 feet and the horizontal movement generally only a few miles. Some of the porosity in the limestones and dolomites beneath the Chattanooga shale is caused by solution at the unconformity at the base of the shale, but much of it is not related to this unconformity, and was probably developed before the formations were deeply buried. There has evidently been no general artesian circulation in the producing horizons.

INTRODUCTION AND ACKNOWLEDGMENTS

Oil and gas have been produced in western Kentucky from strata ranging in age from Ordovician or Silurian to Pennsylvanian. The producing horizons may be divided for convenience into four general groups: the limestones and dolomites of Devonian, Silurian, and probably Ordovician age lying close beneath the Chattanooga shale; the limestones of the Iowan series of the Mississippian; the sandstones of the Chester series of the Mississippian; and sandstones of Pennsylvanian age. The production from each of these groups of horizons has certain

[1]Manuscript received, October 16, 1931.

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distinctive characteristics. According to Jillson,[1] 25,370,666 barrels of petroleum have been produced in western Kentucky from 1918 to 1930.

The data contained in this article were gathered by the writer in the course of field work in the region at intervals during the period extending from 1923 to 1931. The writer is indebted to many geologists and oil producers in the region for geological information and well logs. Particular acknowledgment is due to N. W. Shiarella, R. E. Stouder, and Jack Loman.

The chief purpose of the writer is to describe the producing horizons and structural relations of the oil and gas pools and especially to discuss the problems relating to the origin, migration, and accumulation of the oil and gas.

REGIONAL STRUCTURE

The dominant structural feature of western Kentucky is the Western coal basin, or geosyncline. The differential settling which formed the basin was going on during Devonian, Mississippian, and Pennsylvanian time, for some time after the deposition of the Pennsylvanian coal measures, and during the time interval represented by the unconformities at the base of the Chattanooga shale and at the base of the Pennsylvanian. The Devonian, Mississippian, and Pennsylvanian strata are in general thicker in the central part of the basin than on the flanks. However, in the southwestern part of the previously existing basin there is an area in which the Mississippian strata have been uplifted by post-Pennsylvanian deformation and exposed by erosion. This area is characterized in western Kentucky by intense faulting and by scattered igneous dikes and fluorspar veins.

Another regional structural feature, the Rough Creek fault, crosses the Western coal field of Kentucky east and west, as shown in Figure 1. The structure is a pronounced faulted anticline, with a steep dip on the south side. Just north of this steep dip, there is generally either a single fault downthrown on the north or a structural depression bounded by east-west faults. Several faults branch off diagonally from the Rough Creek fault toward the northeast and southeast.

Some geologists have supposed that the Rough Creek fault is part of an anticline extending across Kentucky. However, the recent geologic map of Kentucky made by the Kentucky Geological Survey (published in 1929) shows clearly that there is no single fault or anticline extending across the state. There is, however, a system of east-west

[1] W. R. Jillson, "Oil and Gas in Western Kentucky," *Kentucky Geol. Survey*, Ser. VI (1930), table, p. 12.

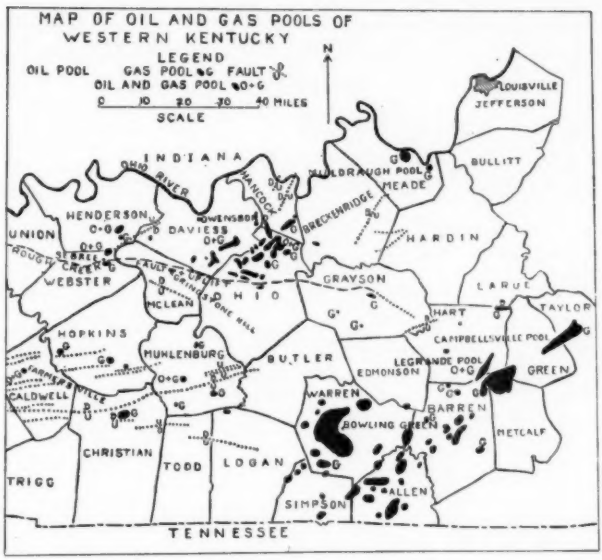

FIG. 1.—Map of oil and gas pools of western Kentucky.

faults and anticlines arranged *en échelon* which extends east and west across Kentucky and which is continuous with the Gold Hill fault of Illinois. The faulted anticlines of this system are characterized by their general east-west strike and by their steep south dip generally bordered on the north by a fault.

The Western coal basin and the Rough Creek fault have of course exerted a profound influence on the accumulation of oil and gas in western Kentucky.

The structure sections (Fig. 2) across the Western coal basin from west to east and south to north show the general character of the major structural features and the thickening of the formations toward the central part of the basin.

SURFACE INDICATIONS

Though in Paleozoic formations, the oil field of western Kentucky is exceptionally rich in surface indications, partly because of the shallow depth of the pools and the exposure of the producing strata at no great distance. The surface indications consist of oil and gas seeps and of sandstones and limestones impregnated with asphalt or tarry substances.

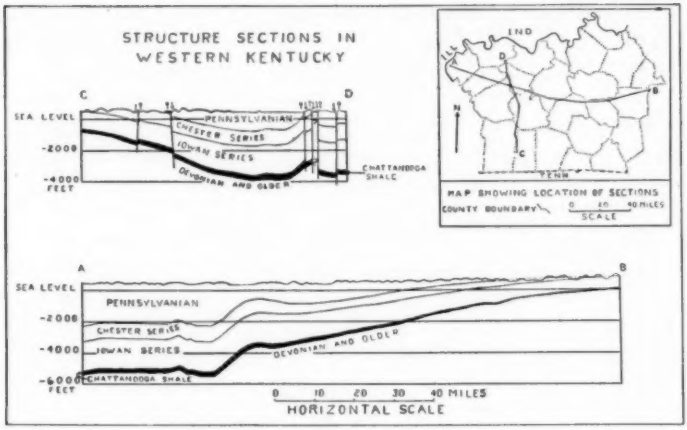

FIG. 2

Oil and gas seeps occur in outcrops of the Silurian and Devonian limestones on the east side of the basin and there are seeps of oil and gas along the Rough Creek anticline in McLean and Webster counties. Asphaltic sandstones are plentiful in the Chester series on the east and southeast sides of the basin. Most of the surface indications are located at the outcrops of horizons that produce oil under cover. The seeps along the Rough Creek anticline where lower Pennsylvanian and even Chester rocks are brought to the surface may be caused by the migration of the oil up the dip through the tilted strata, or they may possibly be due to vertical migration along the fault planes.

RESULTS OF DRILLING TO TRENTON AND OLDER ROCKS

In western Kentucky wells have encountered a "sand" or "sands," 1,700-1,800 feet below the base of the Chattanooga shale, containing salt water but no showings of oil or gas. Several wells have had showings of oil or gas in formations approximately equivalent to the Trenton.

For the convenience of those not familiar with the local stratigraphy, a list of the formations mentioned is shown in Table I.

OIL AND GAS PRODUCTION FROM ORDOVICIAN, SILURIAN, AND DEVONIAN LIMESTONES AND DOLOMITES

PRODUCING HORIZONS

On the southeastern and eastern sides of the western structural basin of Kentucky, oil and gas are produced from strata at depths rang-

ing from 1 to approximately 150 feet below the Chattanooga shale. Most of the production is obtained from the rocks lying close beneath the shale. In certain restricted areas, oil and gas have been found at depths ranging

TABLE I

LIST OF FORMATIONS MENTIONED

Mississippian	Chester series	Kincaid limestone	
		Degonia sandstone Clore limestone Palestine sandstone Menard limestone Waltersburg sandstone Vienna limestone	Leitchfield formation
		Tar Springs sandstone Glen Dean limestone Hardinsburg sandstone Golconda limestone Cypress sandstone Paint Creek limestone Bethel (Sample) sandstone Renalt limestone Aux Vases? sandstone	
	Iowan series	St. Genevieve limestone St. Louis limestone	
Mississippian or Devonian		Chattanooga shale	
Devonian	Middle		
Silurian		Louisville limestone Laurel limestone Osgood limestone Brassfield limestone	
Ordovician		Saluda Trenton limestone St. Peter sandstone	

from 100 to 200 feet below the shale, but generally these lower beds contain water where they are porous.

Some of the producing horizons are limestones; some are dolomites or dolomitic limestones; others, immediately under the Chattanooga shale, are composed of a sand-like mixture of chert fragments and dolomitic limestone, probably an accumulation of the comparatively insoluble residues in the limestones and dolomites as they weathered at the unconformity at the base of the shale.

Near the Le Grande pool, Hart County, where considerable oil has recently been produced, the formations have been named by the operators. The limestone and dolomite, approximately 60 feet in thickness, immediately beneath the Chattanooga shale, are called "Corniferous." The "Corniferous" is the largest producer. Approximately 60-90 feet below the shale is a porous limestone or dolomite known as "Blue sand" by the operators. It generally contains salt water where it is porous. Nearly 100 feet beneath the shale there is in places a yellowish limestone, termed the "Yellow cap." Beneath the "Yellow cap" there is a limestone or dolomite that is in places porous, and above the "Yellow cap" there is locally a red shale. This series resembles the section given by Butts[1] for the Upper Ordovician and Silurian of Jefferson County. This lithologic similarity suggests that the formation below the "Yellow cap" may be the Saluda (Ordovician), the "Yellow cap" is perhaps the Brassfield (Silurian), the red shale may be in the Osgood (Silurian), and the so-called "Corniferous" is possibly the Laurel or Louisville limestone (Silurian). Although the term Corniferous should properly be applied only to Middle Devonian rocks, the operators in Kentucky use it to indicate any producing horizon close beneath the Chattanooga shale. In western Kentucky the so-called "Corniferous" is doubtless both Devonian and Silurian in age.

The oil and gas fields of Allen County have been described by Shaw and Mather.[2]

RELATION OF ACCUMULATION TO UNCONFORMITY AT BASE OF CHATTANOOGA SHALE

During the interval of erosion preceding the deposition of the Chattanooga shale, the underlying strata were tilted slightly toward the western structural basin of Kentucky, as is indicated by the presence of younger strata beneath the shale near the center of the basin. In the central part of the downwarp a considerable thickness of Devonian is present beneath the shale, but farther from the center the Chattanooga lies on the Silurian, and farther out, toward the southeast and south, on the Ordovician. Because of the prolonged erosion before the deposition of the Chattanooga shale, the surface on which it was deposited was generally level; therefore, the Chattanooga actually lies on the bevelled edges of the older rocks.

[1]Charles Butts, "The Geology of Jefferson County, Kentucky," *Kentucky Geol. Survey*, Ser. IV (1915), Vol. 3, Pt. II.

[2]E. W. Shaw and K. F. Mather, "The Oil Fields of Allen County, Kentucky; with Notes on the Oil Geology of Adjoining Counties," *U. S. Geol. Survey Bull. 688* (1919).

This relationship seems to be partly the explanation of two important features of the production from pre-Chattanooga horizons: the concentration of producing areas where the producing strata are at shallow depths on the margins of the basin, and the trend of the fields. The production from the Silurian and Devonian has been almost entirely on the margins of the basin, where these formations lie at depths ranging from 250 to 1,500 feet, and a large part of this production has been from depths ranging from 400 to 700 feet. Some oil has been found in these horizons well down in the basin at Hartford, Ohio County, and at Island, McLean County, but elsewhere the formations beneath the Chattanooga shale have been unproductive in the deeper parts of the basin.

The belt of production extending partly around the basin on its east and southeast sides corresponds approximately with the areas where the porous horizons in the Silurian and Devonian lie close beneath the shale. The slightly greater dip of the lower beds probably carries the porous horizons, if they are present, some distance below the base of the Chattanooga shale in the deeper parts of the basin. The concentration of the production in the belt where they lie immediately below the shale and are bevelled off by the unconformity is in part due to the proximity of the reservoir rocks to the source rocks, in part due to the occurrence of a structural trap, and in part due to the development of porosity in the producing horizons where they intersect the unconformity.

There are fewer known pools in the Silurian and Devonian in the deeper parts of the basin because fewer wells have been drilled to them there. In the central, southern, and southwestern parts of the basin, it is not known what member of the Ordovician, Silurian, or Devonian underlies the Chattanooga shale, or whether the porous horizons are generally present. It is possible that in some sections the porous beds that produce farther up the dip may be close under the shale, or other porous horizons may be present in the overlying rocks beneath the Chattanooga. Therefore, conditions are reasonably favorable for obtaining oil and gas in the pre-Chattanooga rocks in the deeper parts of the basin and on its southwest flank.

On the southeast flank of the basin from the Campbellsville gas pool to the Allen County oil fields, there is a fairly distinct northeast trend of the field as a whole and of some of its separate pools. The general trend of the field has already been explained as a result of the position of the producing horizons close under the shale along this belt. Southeast of this belt they have been removed by pre-Chattanooga erosion, and older rocks lie beneath the shale. The trend of the individual pools is probably

due to the combined influence of porosity, proximity to the source rocks, and structure. Some horizons in the limestones and dolomites have probably been made porous, or have had their original porosity increased, by erosion and solution during the interval preceding the deposition of the Chattanooga shale. The comparatively uniform thickness of the shale indicates that the land on which it was deposited was a plain without much relief. Hence, the ground-water table was close to the surface, and the solution of the limestones and dolomites by meteoric waters did not extend far below the plain. The development of porosity in the strata now beneath the shale was confined to narrowly limited horizons. As each stratum could be affected by solution only where it was near the surface of the plain, the belt in which it was rendered porous would tend to follow its intersection with the unconformity at the base of the Chattanooga shale. This may explain some peculiarities in the trend of the production in the Silurian and Devonian formations, where this production is controlled chiefly by the porosity.

The trend of some of the pools seems to be determined by the structural trap formed by the termination of the reservoir rock against the unconformity. The reservoir rock in these pools contains salt water down the dip, and the belt where it is cut off by the unconformity at the base of the Chattanooga shale is approximately parallel with the strike. The Campbellsville gas pool is evidently of this type. The regional dip in the vicinity of this pool is northwest, and on its northwest side salt water is found in the reservoir rock. The pool itself is long and narrow, with a northeast-southwest trend. On the southeast side, it is reported that no water is obtained beneath the Chattanooga shale, probably because the reservoir rock was removed by erosion before the deposition of the shale. The accumulation is only a few feet beneath the base of the shale, and it is possible that the porosity of the reservoir rock has been produced or increased by solution beneath the unconformity. That the producing formation is remarkably porous is indicated by the fact that, although the rock pressure is reported to have been only 39 pounds per square inch, some of the wells produced as much as 3,000,000 cubic feet of gas per day.

STRUCTURAL RELATIONS OF OIL AND GAS

Oil and gas in the Silurian and Devonian formations are found under structural relations of considerable variety. Where there is a continuously porous horizon containing salt water, oil and gas are found on closed anticlines. Examples of pools of this type are the Muldraugh

field of Meade County, mapped by Stouder, and the gas field in northeastern Hart County, which is on a very pronounced anticline with 100 feet of closure, as mapped by the writer. The accumulation against the unconformity on the up-dip side of a reservoir rock containing salt water has already been mentioned. In some pools the location of productive areas is governed chiefly by the porosity. In the Le Grande pool, Hart County, some gas is found on the up-dip side of the reservoir rock, with oil on the down-dip side. No salt water is found in the reservoir rock in the pool or in the adjacent area on the northwest, or down-dip, side of it. The pool is crossed by anticlinal noses, but the accumulation is evidently controlled chiefly by the porosity. The pool extends for several miles in a general northeasterly direction, parallel with the strike.

SOURCE OF OIL AND GAS

The available data indicate that the richly bituminous black or brown Chattanooga shale is the source of much of the oil and gas in the Silurian and Devonian formations. Most of the oil and gas is found at depths of less than 60 feet below the base of the shale, and much of it is less than 30 feet below. The absence or scarcity of producing formations at greater distances below the shale is not due entirely to the absence of porosity, for plentiful salt water is found in these formations in many places. Nor is it due wholly to the absence of a structural trap, for in wells on closed anticlines water has been found in these lower horizons. However, the few occurrences of productive quantities or merely showings of oil and gas as deep as 150 feet beneath the Chattanooga shale, and showings of oil beneath salt-water horizons, suggest that the source of some of the oil and gas is in the lower beds. Furthermore, it is possible to explain the accumulation of oil and gas in the strata immediately beneath the shale on the assumption that they originated in the lower beds and that the formations below the Chattanooga shale were sufficiently pervious to permit the oil and gas to rise to a position close under the shale.

In some places the relation of the gas production and gas showings to the Chattanooga shale strongly suggest a source from this shale. In eastern Meade County a water horizon, found close beneath the shale, yields gas showings in many places, and gas production from the anticline at Muldraugh. In Hardin County, east and southeast of this belt of water and gas showings, there is an area in which little or no water is found in the horizons close under the shale, possibly because the water reservoir was eroded before deposition of the shale. The water horizon is found at an increasing depth below the shale toward the west, and in

western Breckenridge County it is nearly 300 feet below it. This may be due to the divergence of the lower formations from the shale toward the west, as previously explained, or it may be that the water occurs at different and lower horizons farther west. At all events, the gas showings are confined to the areas in which the water horizon occurs close under the shale. Some gas showings are found in the water horizon where it is 50 feet or more below the shale, but no oil or gas has been reported in it where it is more than 150 feet below the shale, even on closed anticlines. The absence of the gas showings in the water horizon on the closed anticlines indicates that the occurrence of the gas toward the east is due to its migration from the overlying shale, and that the absence of gas showings toward the west is not due simply to its having all migrated away up the dip. If the gas had been present at the west and moved up the dip, one would think that some gas at least would be trapped in the water horizon in the anticlines.

MIGRATION OF OIL AND GAS

For the foregoing reasons, it seems probable that in many places there has been some migration of the oil or gas vertically downward across the strata from the overlying Chattanooga shale. However, this migration is generally less than 40 feet, and the available evidence suggests that no large volume of oil or gas is able to penetrate more than 100 feet downward from the shale. In many places only a few feet of vertical movement would be necessary.

The amount of migration of the oil and gas parallel with the strata varies with the character of the reservoir rock. Where found in isolated porous areas in the limestones and dolomites with little or no water in the reservoir, the oil and gas may not have moved much along the strata, and in some places the accumulation may consist solely in a descent of the oil and gas from the closely overlying shale. Some of the pools are in closed anticlines or other structural traps with salt water and showings of oil and gas in the reservoir rock beyond the limits of the productive areas. In such conditions there has doubtless been some migration up the dip through the reservoirs. Most of the porous horizons in the Silurian and Devonian do not seem to be continuously porous and permeable for great distances, though some of them seem to be persistent for distances of 20-30 miles. It does not seem probable that the oil and gas have moved through the Silurian and Devonian reservoir rocks for great distances from the central parts of the structural basin. It is doubtful if the porous horizons are continuous for such long distances, and some

of the occurrences of water without showings of oil and gas on closed anticlines seem to indicate that there has been little or no migration of oil and gas up the dip through these reservoir rocks since the formation of the anticlines.

In some of the pools there are, however, suggestions that some of the oil and gas may have migrated up the dip 10 or 20 miles to reach the accumulation. This relatively long migration may have occurred in the formation of the Campbellsville gas pool and the gas pool in northeastern Hart County. For nearly 20 miles west and northwest of the Campbellsville gas pool a porous horizon containing showings of oil and gas lies close under the Chattanooga shale. Also, there are anticlinal noses extending west or west-northwest, which may have guided the gas toward the pool as it moved up the dip. An interesting feature of these pools is that, although showings of oil are plentiful in the water horizon down the dip, the production is almost entirely gas. This suggests that the gas has been able to move up the dip and accumulate more readily than the oil.

SURFACE EVIDENCES OF STRUCTURE IN HART, GREEN, AND ADAIR COUNTIES

Interpretation of surface evidences of structure on the southeast flank of the basin has caused marked differences of opinion among the geologists who have examined them. The formations below the St. Louis limestone in this region consist of coarse-grained limestones interbedded with sandy calcareous shales. These strata are extensively cross-bedded, and many seeming dips are produced by deposition on the sides of channels and other uneven surfaces. In some places a bed of limestone may be observed to show a marked dip where the lower strata lie flat. In addition, the shaly strata have been thrown into small, sharp folds that have little relation to the structures large enough to have oil and gas possibilities. Some geologists in this region make maps based on these local dips. In spite of the fact that in this region there are local dips which are due to genuine structural deformation, it seems to the writer that such local dips in this locality are generally decidedly unreliable as a guide to the structure. The only reliable surface structural maps must be based on elevations on a persistent key horizon, and such maps generally show little or no relation to the local dips.

In northeastern Hart County the areal geological county map[1] recently published by the State Geological Survey shows areas of Tertiary cut by faults. If this map is correct, it would indicate faulting after the deposition of the Tertiary, which is contrary to the general conception

[1] "Areal Geologic Map of Hart County, Kentucky," *Kentucky Geol. Survey* (1931).

of the age of the deformation in this region. In northeastern Hart County the St. Louis and St. Genevieve limestones are overlain by somewhat thick deposits of reddish cherty clay and by more or less consolidated sandstones and conglomerates. The sandstones and conglomerates are in places tilted, crumpled, and broken into irregular blocks. In the opinion of the writer, the sandstones and conglomerates are Pottsville and lower Chester rocks which in places have settled into basins and caves formed by the solution of the underlying limestone. Caves and sinks are very plentiful in this region, and the limestones beneath the pervious sandstones and conglomerates dissolve readily, allowing the overlying rocks to settle and crumple or fracture. The supposed Tertiary seems to be weathered Pottsville conglomerate or Chester and Pottsville sandstone, though there may be small patches of Tertiary in the area. In northeastern Hart County, where the county maps of the State Geological Survey show a network of faults, the elevations determined by the writer on a surface key horizon did not reveal any large faults, and it seems probable that much of what is supposed to be faulting is in reality superficial structures caused by settling around sinks and depositional irregularities.

GAS IN CHATTANOOGA SHALE

In most of the wells drilled to it the Chattanooga shale in western Kentucky does not contain oil, gas, or salt water in recognizable quantities. However, in Meade and Grayson counties, according to Stouder,[1] it produces gas on two anticlines and contains salt water in a syncline. It has, however, been drilled on several anticlines of different types in western Kentucky without yielding any oil or gas. Showings of gas have been found in wells in it in several localities, and some of these might have made commercial gas wells if shot. The gas in the shale probably originates in the formation in which it is found.

OIL AND GAS IN IOWAN SERIES

Oil and gas have been produced from several horizons in limestones or dolomites between the Chattanooga shale and the Chester. Although producing areas in these horizons are found here and there throughout a large territory, the quantity of oil produced is generally small compared with that from the Silurian and Devonian and the overlying Chester. In general, the productive areas of the Iowan series are separated and the porosity of the reservoir rock is the chief factor in determining the location of the producing wells. Some of the horizons contain water,

[1]R. E. Stouder, personal communication.

and in these the oil and gas accumulation may be in part anticlinal. In Muhlenburg County some oil is found in widely separated areas from horizons 100-200 feet below the base of the Chester. These horizons are known as the "McCloskey sand" by the drillers. Many of the dry holes disclose no porosity at this horizon; others disclose flows of sulphosaline water.

The oil and gas in the horizons close over the Chattanooga shale may have their source in this shale, or may originate in the overlying rocks. The oil and gas in the higher horizons are probably derived from source beds closely associated with the producing horizons. Certain horizons in the Osage and Meramec groups are locally bituminous, and the writer has obtained oil from them by distillation in the closed tube. Near the base of the St. Louis limestone, there is a widespread occurrence of thin beds of oil shale, some of which are so rich in oil that they will burn.

OIL AND GAS IN CHESTER SERIES

CORRELATION OF PRODUCING HORIZONS

There is much controversy about the correlation of the producing horizons in the Chester series with the formations at the surface. The correlation given by Jillson[1] is inaccurate for some of the producing sands. The formations in the main oil field have been named by the drillers and operators, and their nomenclature and sequence are well understood in the main oil field, which is in northern Ohio, eastern Daviess, and southern Hancock counties. However, the correlations of the drillers and operators generally can not be relied on west and south of this area. Table II gives the formations in the oil field with the drillers' names and the correlation with the surface formations. This table is based on the study of the well logs and on the field work of the writer in tracing the surface formations by their lithology. The publications of the State Geological Survey of Kentucky, particularly those of Stuart Weller, have been used freely.

The Aux Vases? sandstone is fairly persistent in the main oil field. It generally contains salt water, but some oil and gas are produced from it on the structural "highs." In Breckenridge County a thin sandstone is exposed in places at this horizon. It is generally less than 10 feet thick, and is of a patchy or lenticular character. It is in many places underlain by a thin coal. South of Breckenridge County this sandstone disappears,

[1]W. R. Jillson, "Oil and Gas in Western Kentucky," *Kentucky Geol. Survey*, Ser. VI (1930), pp. 8 and 10.

TABLE II

CORRELATION OF CHESTER OIL SANDS

Driller's Name	*Geologic Name*	
Top		
Found but not named	Kincaid limestone	
Possibly stray sand	Degonia sandstone	Leitchfield formation
	Clore limestone	
Possibly stray sand	Palestine sandstone	
Found but not named	Menard limestone	
	Waltersburg sandstone	
Possibly brown lime	Vienna limestone	
Jett sand	Tar Springs sandstone	
Little lime	Glen Dean limestone	
Jones sand	Hardinsburg sandstone	
Big lime	Golconda limestone	
Jackson sand	Cypress sandstone	
Barlow lime	Paint Creek limestone	
Barlow sand	Bethel (Sample) sandstone	
Bethel lime	Renault limestone	
Bethel sand	Aux Vases? sandstone	
Base		

and it has not been reported in the outcrops on the south and southwest sides of the basin.

The Bethel sandstone ("Barlow sand") is one of the main producing horizons of the oil field. It is of a lenticular nature, and in places contains salt water. Some oil and gas have also been found in it in Christian, Caldwell, and Muhlenburg counties on the southwest side of the basin. The Cypress ("Jackson") sandstone is thick and persistent on the southwest side of the basin. In northern Christian and western Muhlenburg counties there is an area where it is absent or very thin, but west of this area it reappears. The Cypress is fairly persistent in the main oil field,

where it generally contains salt water. In places it produces gas on the structural "highs," but in general not much oil is obtained from it. The Hardinsburg ("Jones") sandstone produces considerable oil in the main oil field. It is very lenticular. The Tar Springs (Jett) sandstone is one of the major producing formations in the main oil field. It is very lenticular, excepting on the southwest flank of the basin, where it is more than 100 feet thick in places. On the east and southeast sides of the basin there is in the upper part of the Chester nearly 250 feet of shales with thin limestones and sandstones which are known as the Leitchfield formation. On the southwest side of the basin the Menard limestone replaces the shales in the lower part of the Leitchfield formation. In the vicinity of Butler County the Menard interfingers with the shales in the lower part of the Leitchfield formation, and east and northeast of this it consists only of thin beds of limestone in the lower Leitchfield shale. The term "Stray sand" is applied to two or more sands in the oil field, one of which is basal Pennsylvanian. The "Stray sands" in the oil field are extremely lenticular. In some places gas is found in them, but in many places they contain salt water.

The Kincaid limestone may be traced all the way around the basin from Caldwell County to Breckenridge County. It is present only locally, being in many places removed by erosion during the interval represented by the unconformity at the base of the Pennsylvanian. It everywhere contains peculiar fossils with a concentric structure, which were not observed in the lower limestones.

The subsidence of the structural basin of western Kentucky continued during the deposition of the Chester series and during the interval of erosion represented by the unconformity at the base of the Pennsylvanian. For this reason, the Chester is thicker in the central parts of the basin, and there the basal Pennsylvanian beds lie on members of the series that are younger than those on the flanks of the basin toward the southeast. As previously stated, the faulted area on the southwest flank of the present basin probably represents a deeper part of the basin that has been uplifted and eroded. In this region the Pennsylvanian lies in places on the Kincaid limestone, and farther east and southeast it lies on progressively older members of the Chester. In parts of Hart, Larue, and Green counties the entire Chester has been removed, and the Pennsylvanian lies on the St. Louis or St. Genevieve limestones.

RELATION OF ACCUMULATION TO STRUCTURE

Most of the reservoir rocks in the Chester are markedly patchy or lenticular in their distribution, and this condition has had a dominant

influence on the oil and gas accumulation. Some oil is produced from lenticular sandstones on nearly flat monoclines. The strata north of the Rough Creek fault, where production is best, are, however, more or less folded, and some of the oil is found on the anticlines. Because of the occurrence of salt water in parts of the producing rocks, the chances for finding oil are in general much better on the closed anticlines than in the adjacent synclines, though porosity is everywhere an important factor, and many closed anticlines in the surface rocks have failed to be productive because of the absence of a reservoir rock of suitable porosity. The reservoir sandstones may be absent entirely—that is, they may be replaced by shale or limestone—or they may be present but too shaly, too limy, or too tightly cemented by silica for commercial production. It is a common occurrence to find the sandstones containing oil but too impervious for production. The Rough Creek fault has evidently had a marked effect on the porosity of the sandstones along its course. In the belt of steep folding and pronounced faulting, the Chester sandstones are in many places too hard and tight for production of appreciable quantities of oil, gas, or water, though they yield these fluids freely a few miles away from this belt of intense deformation. For example, near Beech Grove, McLean County, and Sebree, Webster County, in wells drilled on very steep anticlines with large closure close to the fault, little or no water was found and only showings of oil and gas, though in wells just north of these extremely disturbed strata there are plentiful flows of salt water in these sandstones. The highly tilted sandstones near the fault are hard and tight because of the deposition of siliceous cement between the grains. Some of the Chester sandstones in the areas of maximum disturbance are almost quartzites.

The location of the best production in an area north of the Rough Creek fault and extending along it, has long puzzled the oil operators. In this belt the strata are thrown into gentle folds, though farther north the deformation is less pronounced. There is also little or no folding in the eastern part of this productive belt. Immediately south of the productive area the strata are raised by faulting, and south of this fault they dip steeply southward. North of the main area of production north of the fault, there are some oil pools, but they are more widely separated and less prolific than in the belt just north of the fault. No very productive area has been found in the steeply tilted rocks along the fault or on the steeply dipping south flank of the uplift. Some oil is produced from this south flank at Grindstone Hill, McLean County, and some gas from the south flank of the anticline south of Sebree, Webster County.

South of the Rough Creek uplift, the strata dip at a moderate and diminishing rate toward the Moorman syncline. Some folds and faults are present, but no very productive pools, like those north of the fault, have been found.

The location of the area of best production is probably determined in part by the nature and distribution of the source beds. The scarcity of oil in the steeply dipping beds along the uplift is due to the reduction of the porosity in the sandstones, as a result of pressures involved in the folding. The scarcity of oil in the eastern part of the area south of the Rough Creek fault may be ascribed to the thinning of the sandstones, excepting the Cypress, in that direction, and to the lower porosity of the producing sandstones in this section. As there is no reason for the deposition of the richest source rocks in a belt just north of the present fault, it is possible that the pressures which produced the fault have been effective in generating the oil and gas in the source rocks or in forcing them from the source rocks into the reservoir rocks.

The oil at Grindstone Hill and the gas south of Sebree may have migrated up the dip and accumulated against the fault or against the tight sandstones along the fault. However, the oil field north of the Rough Creek fault did not originate in this manner. The regional dip in the eastern part of this belt is west, parallel with the fault, and farther west it is west-northwest. There is, therefore, no chance for the fault to form a closure. Furthermore, there is in many places a syncline between the fault and the oil pools.

In the southwest side of the basin, oil and gas have been found in the Bethel and Tar Springs sandstones in Muhlenburg and Christian counties. These accumulations do not seem to be anticlinal and are probably due chiefly to the porosity or to the location of the source rocks. In Caldwell County near Farmersville oil and gas have been found in the Bethel sandstone on an anticline mapped by Stuart Weller.[1] This accumulation is in a general area of pronounced faulting and in close association with some igneous dikes. Though the oil and gas are not yet being produced from this area, their occurrence suggests that faulting and igneous dikes are not as unfavorable for oil and gas production as some geologists have supposed.

The thickening of the Chester sandstones toward the northwest has had an important influence on the oil and gas production from these rocks. Farther east the accumulation has probably occurred as a result of lenticular sand conditions, but toward the northwest it is more closely

[1]Stuart Weller, *Kentucky Geol. Survey*, Ser. VI, Vol. 6 (1922).

related to anticlines. The reason for this is to be sought in the relative volumes of the reservoir rocks and the source rocks. Toward the east the reservoir rocks are thinner and the source rocks probably thicker or richer. Hence, enough oil is produced so that a large part of the reservoir rock is filled with oil even without the presence of an anticline. Toward the west, on the contrary, the volume of the oil is not enough to make a commercial accumulation until it has been concentrated by the anticlines.

SOURCE OF OIL AND GAS IN CHESTER SANDSTONES

Some geologists have supposed that the oil and gas now in the Chester sandstones have migrated up through faults or fissures from the bituminous Chattanooga shale. The alternative theory is that they originated from bituminous Chester strata in close association with the sandstones in which they are found. The asphalt in the Chester sandstones at or near their outcrop evidently represents former deposits of oil which have been subjected to evaporation and chemical reaction with oxygen or substances in the ground water near the surface. Hence, its origin is probably the same as that of the oil deposits in the same sandstones where they lie under greater cover.

If the oil had migrated up through the faults, one would expect that the greatest accumulations would lie close to them. Though the best oil accumulation is within a few miles of the Rough Creek fault, it seems clear to the writer that the oil did not reach its present position by moving up along the plane of the Rough Creek fault and spreading out laterally through the sandstones. If this were true, one would expect that the oil accumulation would be greatest at the faults and would diminish within a short distance from them, but this is not the fact. If the oil came from the Rough Creek fault plane it would in many places have had to migrate either down the dip or along the strike for several miles in order to reach its present position. In doing so, it would have had to cross synclines in which water is now found in the producing horizons. The fact that the producing horizons are extremely lenticular is also against this supposition.

There is no reason to suppose that open fissures now exist along the fault planes. Where the faults in western Kentucky traverse limestones, these hard rocks are generally cut by fractures completely filled by calcite. Along many of the faults in this region there is much drag, and some of the faults pass into very steep monoclines. In fact, some of the breaks that are mapped as faults are, at places in their course, steep monoclines

in which the strata are bent so that they dip at angles of 10° or more with only a minor amount of true faulting. Any upward movement of oil or gas along such faults would presumably soon be diverted laterally.

If the oil and gas have come into the Chester sandstones by upward movement through faults, one would expect that the greatest accumulations would be in the areas where the faults are most plentiful. This, however, is not the fact. The belt of maximum production north of the Rough Creek fault is only slightly faulted, and only minor amounts of oil have been found in the region of severe faulting on the southwest side of the basin.

The strongest argument against the theory that the oil and gas originated in the Chattanooga shale or other deep-seated rocks is found in the fact that the accumulation is concentrated in certain members of the Chester, and in the fact that water horizons nearly devoid of oil and gas lie between the Chattanooga shale and the producing horizons. In the oil field north of the Rough Creek fault, most of the oil is produced from the Bethel, Hardinsburg, and Tar Springs sandstones. The Aux Vases sandstone ("Bethel"), which lies beneath the producing horizons, commonly contains water in this area, and the Cypress sandstone, which lies between the producing formations, also generally contains water. A water horizon is commonly found in the oil field nearly 250 feet below the base of the Chester, and it is generally devoid of oil and gas, even on closed anticlines. Water horizons also lie between the asphalt deposits of Edmonson County and the Chattanooga shale. If the oil and gas have come up from the lower formations, one would certainly expect that the porous horizons nearest the source would contain the most oil and that the least would be found in the upper horizons, which is clearly not the fact. The character of the Chester strata, which consist of alternating sandstone, limestone, and considerable shale, is also decidedly unfavorable for long vertical migration. The fact that the producing formations are separated by the water-bearing Cypress sandstone suggests that all the oil and gas did not come from a single source bed in the Chester, but that there were bituminous rocks from which they were derived at several horizons. The writer has obtained oil by distillation in the closed tube from dense limestones and dark shales of the Chester series collected from the outcrops, and it is probable that the oil in the producing fields comes from beds of a similar nature in close association with the producing strata.

As some of the accumulations are on anticlines surrounded by salt water in the producing horizons or in the up-dip terminations of the sand

bodies, it is evident that some lateral migration of the oil and gas into the accumulations has occurred. On the contrary, the occurrences of sand lenses which seem to be completely filled with oil suggest that the oil has been derived from adjacent rocks without much lateral movement. The general migration of the oil for long distances through the producing horizons would be prevented or impeded by their generally non-persistent character and by the presence down the dip of anticlines or faults which might prevent movement across them.

The evidence regarding the accumulation of the oil in the Chester series suggests that the vertical movement across the strata is generally less than 100 feet, and that the lateral movement is ordinarily only a few miles.

OIL AND GAS IN PENNSYLVANIAN SANDSTONES

Oil and gas are produced from several different horizons in the Pennsylvanian in western Kentucky, and asphalt is also found in the lower sandstones of this age in Edmonson and Grayson counties. The best production in the Pennsylvanian is from a lenticular, more or less pebbly sandstone deposited in a channel cut into the underlying Chester. This channel lies in the belt of Chester production north of the Rough Creek fault in Ohio County. According to N. W. Shiarella,[1] who has made a study of this channel production, the stream which excavated the channel evidently flowed in a west-northwesterly direction. Oil is commonly found where the producing formation is encountered in sufficient thickness and porosity. The initial production of the wells is exceptionally large for their depth, which is only approximately 400 feet. The producing sandstone is known as the "Stray sand," and should not be confused with sands in the upper part of the Chester, which are also called "Stray." The production from the channel has no relation to the structure, but depends entirely on the sand conditions and the proximity to the source rocks. A shale overlies the producing horizon, and has doubtless prevented the oil from rising into the higher Pennsylvanian sandstones. Weller[2] has described a deposit of asphalt in Edmonson County in Pennsylvanian sandstones and conglomerates filling a similar channel cut into the underlying Chester. The oil in the Ohio County channel probably originated in the Chester shales and limestones which form the walls. The asphalt may have come from the Chester or from the closely underlying rocks of the Iowan series.

[1] N. W. Shiarella, personal communication.

[2] J. M. Weller, "Geology of Edmonson County, Kentucky," *Kentucky Geol. Survey*, Ser. VI, Vol. 28 (1927), p. 206.

In drilling to the deeper formations, shallow gas has been found in the Pennsylvanian sandstones on several anticlines, but in many places the volume is too small or the area too limited for commercial production. The best oil production from the Pennsylvanian, aside from the production in the channel, is in the Niagara pool in Henderson County. This production is from the top and down-dip flank of a closed anticline, and the sand is in the lower part of the Pennsylvanian series. The best gas production in the Pennsylvanian is generally found in a fairly persistent sandstone nearly 400 feet below Coal No. 9. Gas has been found at nearly this horizon in several localities. The sandstone is productive on the top and down-dip flank of a closed anticline 3 miles northeast of Sebree, and on the anticline at Niagara. The Pennsylvanian sandstones generally contain salt water, and the production from them is ordinarily anticlinal. Most of the sandstones, however, are lenticular and irregular, and there are many dry holes on the anticlines due to the absence of the producing horizons. Some oil and gas have also been found off structure. The oil, gas, and asphalt in the basal part of the Pennsylvanian may have originated in the underlying Chester, but the oil and gas in the higher strata, separated from the Chester by water horizons and shales, more probably came from bituminous beds within the Pennsylvanian.

ORIGIN OF POROSITY IN LIMESTONES AND DOLOMITES

In western Kentucky there are several different porous horizons in limestones and dolomites ranging in age from Saluda (Ordovician) to St. Genevieve (Mississippian). The limestones between the St. Peter and the Saluda generally have little or no porosity, and, so far as known, the limestones of the Chester series and the thin limestones of the coal measures are not porous either in unweathered exposures at the surface or where penetrated by the drill. Some of the porous horizons are dolomites or dolomitic limestones; others are limestones, though they may be slightly dolomitic. Porosity due to residual accumulations of relatively insoluble materials at the unconformity at the base of the Chattanooga shale has already been mentioned.

It seems that the porosity of the limestones and dolomites has been developed in two ways. Some of the porous horizons have been developed by solution beneath the unconformity at the base of the Chattanooga shale. Others are seemingly not related to this unconformity, and their porosity either originated before the strata were deeply buried or is related to minor unconformities. The unconformity at the base of the Chattanooga shale intersects different horizons of limestone and dolo-

mite, but only a few of these have been rendered porous by the erosion at this unconformity. Pronounced unconformities, underlain by limestones, are found at the base of the Chester and at the base of the Pennsylvanian, but are evidently not generally underlain by porous horizons formed by solution beneath them. It is evident that only limestones and dolomites of certain peculiar characteristics are rendered porous by solution at unconformities. This seems to be true elsewhere, for only a small part of the limestone formations beneath unconformities have been rendered porous by solution at the unconformities.

Some of the cavities in the porous limestones and dolomites are irregular in shape. Some that have the shape of fossils are in dolomitic rock, and the shells have been removed because of their greater solubility. Remnants of the partly dissolved shells are found in the pores. In the exposures of the Silurian and Devonian rocks on the flanks of the Cincinnati anticline, there are strata of non-porous dolomite which contain numerous scattered grains that effervesce freely with acid. Rocks of this type may become porous when weathered, because of the more rapid solution of the grains containing less magnesium. A porous horizon occurs locally in the outcrops at the base of the St. Louis limestone. It is interbedded with non-porous limestone, and no sign of an unconformity was observed above it.

The manner in which some of the porous strata diverge from the unconformity at the base of the Chattanooga shale seems to indicate clearly that much of the porosity in the Silurian and Devonian limestones and dolomites did not originate by solution beneath the unconformity at the base of the shale. In Meade and Breckenridge counties, as already stated, the depth to the first water below the shale increases toward the west from a few feet to nearly 300 feet. Because of the flatness of the topography on which the Chattanooga shale was deposited, it is not probable that erosion and solution extended far below the surface. Hence, porous horizons more than 100 feet below the shale are presumably not related to this unconformity, especially where they diverge from it and where they are overlain by a thick series of limestones lying below the unconformity but showing no sign of porosity.

The exposures in the arid and mountainous regions of the west afford a better opportunity to study the nature of the porous zones in the limestones and dolomite than are found in Kentucky. In examining the limestones and dolomites of Mississippian, Pennsylvanian, and Permian age in West Texas, New Mexico, and western South Dakota, the writer noticed that the porous dolomitic horizons were in many places

interbedded with limestones showing no sign of porosity, that the dolomites were more porous than the associated limestones, that the pores in some places have the shapes of fossil shells, and that in many places there is no indication of an unconformity in the overlying rocks for a considerable distance above the porous beds. There is also, in many places, no sign of solution channels such as one would expect if the porosity were produced by weathering beneath an unconformity. Furthermore, one would expect that the limestone layers would be more affected by the solution than the interbedded porous dolomitic strata. However, these closely associated limestone beds generally showed no sign of weathering or solution. These relationships suggest that porosity originated before the strata were first buried. Though the dolomites are in general more porous than the limestones, by far the greater volume of the dolomites examined showed no sign of porosity.

When first deposited, some limestones consist of calcareous muds or sands of great porosity. This porosity is, of course, generally nearly lost before the limestone has been deeply buried or consolidated. This quick loss of porosity is presumably due to the solubility of the limestone. As the pressure on the mass increases, the grains go into solution at their points of contact, and the dissolved material is redeposited in the spaces between them, thus filling the pore space. It is, however, conceivable that some limestones would be consolidated firmly enough to bear the weight of the overlying sediments while retaining much of their porosity, in which condition a porous horizon in the limestone might be formed without the aid of subsequent erosion and weathering beneath unconformities. Solution of the limestones and dolomites may also have occurred while they lay on the sea floor, before being deeply buried. Dolomites, being less soluble, would probably not readily lose their original porosity by consolidation; furthermore, if the limestone was changed to dolomite before burial, the solutions which brought in the magnesium and carried away the calcium might dissolve away some of the calcium without replacing it, thus leaving a void. It has been supposed that during the change from limestone to dolomite the porosity is produced by the contraction in volume caused by the increasing density. However, if this were true, it is difficult to see why many of the pores should have the shapes of fossils. Though many porous horizons are caused by solution beneath unconformities, the field evidence suggests that some of the porosity in limestones and dolomites is original porosity or porosity that has originated by solution before the strata were deeply buried.

POSSIBILITY OF ARTESIAN CIRCULATION AND LONG-DISTANCE MIGRATION OF OIL AND GAS

It is an interesting fact that most of the oil and gas produced in western Kentucky is obtained from more or less lenticular reservoirs, and the more persistent pervious beds may contain only water. This may at first suggest that the oil and gas have been flushed from the more persistent porous horizons by artesian circulation. The more persistent water-bearing beds of the region are the St. Peter sandstone, the horizon nearly 250 feet below the base of the Chester in the area north of the Rough Creek fault, the Aux Vases? sandstone in parts of the same region, the Cypress sandstone, and the thick sandstone or conglomerate at the base of the coal measures. This last sandstone is irregular in thickness and character, but generally contains water.

With the exception of the St. Peter sandstone and the basal sandstone of the coal measures, both of which contain fresh or brackish water in certain areas, all the more persistent porous horizons of western Kentucky are filled with salt water away from their outcrops. This presence of salt water presumably indicates the absence of extensive artesian circulation. Extensive artesian circulation would result in the original salt water being displaced by fresh water from the outcrops, and, if this has occurred, the fresh water must again have been displaced by salt water. No doubt a limited amount of salt water would be expelled from the underlying formations during their compaction, but, unless the circulation stopped before the sediments were compacted, it seems improbable that fresh water in so many extensive horizons could be replaced by salt. That there has been no extensive artesian circulation in the producing formations is indicated by the foregoing evidence, as well as by the lenticularity and non-persistent character of the reservoirs from which the oil and gas are obtained. It seems very improbable that artesian circulation has caused any oil or gas accumulations in this region.

As far as the writer knows, there is no reason for assuming a migration of oil or gas through great distances in this region. The limited migration assumed by the writer seems competent to account for the known accumulations. The comparative rarity of oil and gas in the more persistent porous horizons may be explained by the absence of source rocks in close association with them, and by the comparative rarity of structural traps in them. In the less persistent horizons, every lens or termination of the reservoir up the dip forms a trap in which oil and gas may accumulate, but in the continuously porous and pervious beds, good traps for the accumulation of oil and gas occur only in the closed structures.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
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GEOLOGICAL NOTES

CAMERON MEADOWS AND IOWA, TWO NEW COASTAL LOUISIANA FIELDS

Within a single week in October, 1931, the Vacuum Oil Company (now Magnolia Petroleum Company) brought in two Louisiana Gulf Coast fields of major importance. The first of these, Cameron Meadows, 40 miles southwest of Lake Charles, is in Cameron Parish, only 5 miles from the Gulf, and the second, Iowa, is 12 miles east of Lake Charles in Calcasieu Parish. Both fields are located on deeply buried salt domes whose discovery resulted from the recognition of surface indications and geophysical work. To Henry C. Cortes, in charge of the Vacuum's coastal geological and geophysical work, is due the credit for these promising discoveries. Cameron Meadows is in Sec. 21, T. 14 S., R. 13 W., and Iowa is in Sec. 13, T. 9 S., R. 7 W.

The Cameron Meadows dome was intimated by gas seeps known to trappers in the marshes covering this area. These seeps were brought to Cortes' attention in March, 1926. At the opportune time, leases on more than 18,000 acres were taken by the Vacuum and geophysical work commenced. A significant gravity minimum indicating deep salt was found which was later confirmed by both refraction and reflection seismograph work.

The first well, Cameron Meadows No. 1, was begun in February, 1930. After encountering several oil and gas showings, the drill stem was blown out of the hole at a depth of 3,814 feet. The well was deepened to 5,248 feet to a good oil sand in the Miocene, but, due to mechanical difficulties, a test of this sand was impossible and the well was completed as a small gas well at 3,850 feet.

A second well, Cameron Meadows No. 2, was then drilled 500 feet south of No. 1, and after several shallow oil and gas sands were found, 10 feet of oil sand from a depth of 5,263 to 5,273 feet was tested, resulting in 2,400 barrels of pipeline oil, 41.2° Bé., on a ½-inch choke, on October 10, 1931. Although this producing depth is close to the depth of the last sand in the first hole, it is not certain that both sands are the same.

The Iowa dome, on which the first producer was Waite No. 1, at a depth of 6,971 feet, a few days after the Cameron Meadows discovery,

was also marked by surface gas seeps that had attracted the attention of Lee Hager as early as 1916. In 1923 the Gulf Company, also drawn to the area by the seeps, drilled to 3,381 feet, 2½ miles north of the discovery well, and again in 1926 the Union Sulphur Company, after some refraction seismograph work, drilled 2 wells 2½ miles northeast of the Vacuum well, the deepest to 4,850 feet. Finally, the Vacuum Company, because of the favorable character of the gas seeps, undeterred by these failures, assembled a block of leases for geophysical work. However, before this work could be commenced, the Shell Corporation, while shooting another area by refraction methods, picked up a fast shot indicating salt and took a block of leases adjoining the Vacuum's block on the south. Torsion-balance work by the Vacuum definitely showed deep salt, which was confirmed by both refraction and reflection shooting.

A well was commenced in December, 1930, in which was found 7 feet of Miocene oil sand at a depth of 5,008 feet. This sand produced 4,500 barrels of 29.9° Bé. oil before going to water. The well was then deepened to an Oligocene sand, 628 feet below the *Heterostegina* limestone, at a total depth of 6,971 feet. Fourteen feet of clean oil sand here, when tested, yielded pipeline oil at the rate of 3,150 barrels daily through two ⅜-inch chokes and one ½-inch choke, 40.6° Bé. gravity.

These two fields are clean-cut examples of the value resulting from the intelligent correlation of an intensive study of surface salt-dome features and modern geophysical methods. They show that surface manifestations of buried salt domes, a class of evidence that has recently lost its significance in the minds of some students of salt domes, may still point the way to new oil fields. These fields are also notable, although perhaps less so than fields of shallower domes, in that the first well on each prospect would have been productive, had not one of them failed because of mechanical trouble.

L. P. TEAS

HOUSTON, TEXAS
February 1, 1932

DISCOVERY OF OIL AT GREASEWOOD FLATS, WELD COUNTY, COLORADO

Platte Valley Petroleum Company completed its Patterson No. 1 in the NE. cor., SE. ¼, Sec. 24, T. 6 N., R. 61 W., Weld County, Colorado, on October 10, 1930, at a depth of 6,661 feet, flowing at the rate of 184 barrels per day. The well was subsequently deepened several

times with slight changes in production and settled to a flow of 350 barrels per day for more than 9 months. At the present time, more than 15 months after its discovery, the well is flowing 112 barrels per day. The oil is coming from what is presumably a lenticular sand in the basal Benton shales of the Colorado group of the Cretaceous. Two other flowing wells have been completed in the field, and another well, from which has been swabbed considerable oil, remains in a nearly completed condition.

The geological work on which this discovery was based was done by Charles S. Lavington, who was working under the direction of R. D. George, state geologist. This work was done in December, 1923, and January, 1924, Lavington being employed by the Greeley Chamber of Commerce to examine Weld County for its oil and gas possibilities. The results of Lavington's field work were published in February, 1924, in a bulletin entitled "Reconnaissance of the Cretaceous Area of Weld County, Colorado." In that bulletin and on the map accompanying it Lavington directs attention to the northwest-trending anticline in the Greasewood Lakes area in T. 6 N., R. 61 W.

Although Mr. Lavington's work, in an area of nearly 4,000 square miles, done in the middle of winter, and in the limited time of approximately 5 weeks, is necessarily subject to some errors, it is in its major features more reliable than any published articles on the area which have appeared subsequently. The main discrepancies in Lavington's original work (as he readily admits) are in giving too great amounts to his dip readings. Lavington was the first one to call attention to the structure of the area, and, although the subsurface structure seems to have little if any relation to the production, credit for the discovery is due entirely to his original work.

HARRY W. OBORNE

BOX 57
COLORADO SPRINGS, COLORADO
January 27, 1932

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
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DISCUSSION

FRIO CLAY, SOUTH TEXAS

Although I have been away from Texas eight years, I have been following with interest the discussion in this *Bulletin* of the nomenclature of the two formations lying between the Oakville and Fayette in south Texas. This discussion began with a proposal by Julia Gardner and A. C. Trowbridge[1] of a new name, Yeager clay, for Dumble's[2] "Frio clay," as it was restricted and redefined by me.[3] They also proposed to use Dumble's name, "Frio," for the overlying pyroclastic beds to which I had applied the name, "Gueydan." The committee appointed by the San Antonio Geological Society (E. H. Finch, *chairman*, Phillip F. Martin, Olin G. Bell, and R. F. Schoolfield[4]) have called attention to the error in Gardner and Trowbridge's statement that "unfortunately Dumble's original description includes only outcrops of the volcanic series" by quoting Dumble's original description of his Frio which includes *gypseous clays* just above the Fayette. The committee of the San Antonio Geological Society is to be congratulated on its clear and fair-minded report. I do not believe that I committed a crime against all previous recognized usage when I restricted a formational name to a certain part of a previously described "formation" after more detailed work had shown that two formations were included in the original "formation." Such instances are not uncommon in accepted geologic literature. I agree with the committee that no particular type locality was selected from the "wide area of typical exposures"[5] mentioned in Dumble's 1894 paper. I relied on Dumble's oral statement made in 1923 that the type locality of his Frio was near the mouth of Frio River, northwest of Three Rivers, although this does not seem to be specifically selected as the one and only "type locality" in his early published descriptions. Otherwise I should not have made the confusing statement on page 48 of my 1926 paper, that "the type locality (of the Frio) then described (by Dumble, 1894) occurs in the upper Gueydan formation."

I was very glad to see in F. H. Lahee's[6] article, which included an extract from a letter of W. C. Mendenhall to E. H. Finch, that the U. S. Geological

[1]"Yeager Clay, South Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, No. 4 (April, 1931), p. 470.

[2]E. T. Dumble, "The Cenozoic Deposits of Texas," *Jour. Geol.*, Vol. 2, No. 6 (1894), pp. 554-55.

[3]Thomas L. Bailey, "The Gueydan, a New Middle Tertiary Formation from the Southwestern Coastal Plain of Texas," *Univ. Texas Bull. 2645* (1926), pp. 44-52.

[4]"Yeager Clay, South Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, No. 8 (August, 1931), p. 967.

[5]*Op. cit.*, p. 968.

[6]"Frio Clay, South Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 16, No. 1 (January, 1932), pp. 101-2.

Survey had decided to use "Catahoula tuff" for my "Gueydan" and the name, "Frio clay," for the true clay part of Dumble's original "Frio clay." While writing my paper on the "Gueydan" I had considerable difficulty in deciding whether to name the pyroclastic formation "Gueydan" or "Catahoula." I finally decided to use a new name, for the following reasons.

1. There is a great difference in facies between the Gueydan of southern Texas, as I defined it, and the Catahoula formation at its type locality in Louisiana.

2. I was (and am) uncertain as to the *complete* equivalence of the Gueydan to the Catahoula at the type locality of the latter. The more or less tuffaceous, fluviatile clays and "reworked tuffs" of the upper Gueydan, Chusa member, especially in Karnes and Gonzales counties, are lithologically quite similar to certain parts of the Fleming clay of East Texas, and a part of the Fleming may possibly be included in my Gueydan in addition to the Catahoula formation.

I had no intention of creating dissension when I introduced the name, "Gueydan," and I believe that the foregoing reasons justify my introduction of it into geologic literature. However, I am quite willing to abandon the name, "Gueydan," in favor of "Catahoula tuff" if the majority of geologists who have worked in the area prefer "Catahoula." In fact I stated on page 15 of my 1926 paper:[1]

> If the pyroclastics and associated rocks which are called in this paper the "Gueydan formation" are to be placed in one of the previously recognized stratigraphic divisions of the Texas Coastal Plain section, they should be placed in the Catahoula, their partial or complete equivalent.

It is vastly preferable and less confusing to call the Gueydan formation "Catahoula tuff," in spite of the fact that a considerable part of it is not a true tuff, than to call it "Frio," which name has generally been associated, since 1894, with clays immediately above the Fayette.

THOMAS L. BAILEY

VENTURA, CALIFORNIA
January 24, 1932

CARRIER BEDS AND OIL ACCUMULATION

In the following discussion of two papers recently published in the *Bulletin*[2] the writer attempts to examine critically the fundamentals on which Rich's conclusions are based.

Rich commences his discussion by stating that certain known facts require as an explanation *extensive* migration. These are: (1) structural control of accumulation; (2) great accumulations of oil in relatively small areas; (3) the fact that "in many places oil does not seem to have been derived from local

[1] Thomas L. Bailey, *op. cit.*

[2] John L. Rich, "Function of Carrier Beds in Long-Distance Migration of Oil," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, No. 8 (August, 1931), pp. 911-24; "Source and Date of Accumulation of Oil in Granite Ridge Pools of Kansas and Oklahoma," *op. cit.*, No. 12 (December, 1931), pp. 1431-49.

sources and fails to show any definite relation to local source rocks"; and (4) the fact that oil has been flushed out of rocks in areas having strong artesian circulation.

Obviously, gravitational adjustment within a "structure" would explain the relative position of oil and water in that "structure."

As for the great accumulations, let us consider a hypothetical oil field in which the oil sand, which is 45 feet thick, has a 50 per cent oil recovery and that this recovery is 15,000 barrels per acre, making a total oil content of 30,000 barrels per acre, or 2,000 barrels per acre yard, or (approximately) 0.4 barrel per cubic yard. If a drainage area, only six times as great as the producing area, be further assumed, and if there has been no migration from outside this limited area, it is necessary to account for the formation of only 0.067 barrel of oil per cubic yard of sediment, or approximately 1½ gallons per ton. But Trask reports yields on distillation of organic matter in recent sediments ranging from 2 to 28 gallons of oil per ton of sediments.[2]

Gardner, in his discussion of Rich's first article (pp. 922-24), deals adequately with the question of source rocks, and the present writer agrees that the invention of the term "source rocks" need not be considered proof of the existence of rocks of this kind.

As for the flushing of oil from rocks having strong artesian circulation, that is entirely probable. Oil is flushed from oil sands wherever this circulation exists, unless too rapid removal of fluid brings about by-passing, but it must be noted that such artesian circulation can exist only where there is an outlet, such as a seepage, spring, or drilled well, either on the earth's surface or beneath the sea. This point seems to be forgotten by most upholders of the hydraulic theory of oil accumulation.

Figure 2 (p. 915) shows a decrease in surface tension with rising temperature. Although the curves as extrapolated are assumed to be correct, their bearing on the migration of oil through rocks is not evident, as they give the surface tension between oil and air and water and air, respectively, and have been measured by noting the size of drops of these liquids falling from a capillary tube, a condition which is very different from artesian circulation at a depth of several hundred or several thousand feet, where the liquids are coming in contact with rock, not air.

However, even if a decrease in viscosity and surface tension with increasing temperature be admitted, as there is undoubtedly reason for doing, this does not seem to affect artesian circulation, for in a circulatory system no fluid can flow faster than the fluid ahead of it, save for slippage or by-passing, and in such a system as that postulated by Rich the flow would be regulated by the flow of these liquids at the outlet—in other words, under conditions of viscosity and surface tension prevailing at or near the earth's surface. If the outlet is sealed, there is no circulation; if flow at the outlet is slow, circulation is slow; and if flow at the outlet is rapid and circulation correspondingly rapid, the sorting action by means of which oil is diverted into traps while the water moves onward and upward becomes very difficult to understand, particularly if, as Rich would seemingly have us believe, their viscosities and surface ten-

[2]Parker D. Trask, "Does Petroleum Form in Sediments at Time of Deposition?" *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 14, No. 11 (November, 1930), p. 1452.

sions are more nearly equal than the fluids with which we are familiar. If Rich's arguments were sound, rapid pumping of very deep wells would not cause coning to the extent that it does.

With Rich's view that the mode of entrance of oil into the carrier bed is of relatively little importance, as far as this particular problem is concerned, the writer can not agree. Two methods are suggested by Rich, namely, the squeezing out of oil from source beds by compaction, and passage along fractures. The writer can not visualize the process by means of which compacting sediments convert solid bituminous substances into liquid hydrocarbons, because this process involves an increase in volume, and reactions at high pressures tend to go in the direction of decreased volume. There are other details connected with the idea of compaction which the writer does not fully understand, but a discussion of these details at this point would be irrelevant.

The writer has published certain details relative to the absorption of oil by limestone[1] and recently chanced on a note to the effect that a road-building company finds that asphalt is absorbed by, and binds firmly, macadam that has been oil-soaked, whereas the results with untreated macadam show very little absorption.[2] Rich's reference to grahamite dikes and veins is merely additional evidence that large quantities of oil do not flow through fractures without having so much of their light constituents absorbed that the heavy residues will seal the fractures, thus preventing further flow.

In all of Rich's later discussion of circulation within the carrier, he omits to mention what happens to the water after it has left the oil behind in the conveniently located trap. He also omits to explain why oil, having left an impervious bed for a porous carrier, leaves the latter for a less porous reservoir, and also why the fluid already in this reservoir should retreat in the face of the invading fluid, presumably into still other saturated rocks.

If, as Rich says, there is upward leakage of fluids in anticlines and around salt domes, why do these structures form traps? Is there differential trapping? Or differential leakage?

If a salt dome acts as a center "toward which oil and water would converge from many miles around," where do the fluids go after they have converged? Rich's answer that "If its closure were adequate it would screen out and trap the oil" is not complete. The writer conceives the process to be somewhat as follows: the oil and water converge upon the salt dome; then the water, having deposited its oil, turns around and diverges again, taking care to avoid additional converging water which is bringing up more oil.

It seems very much simpler to avoid such complicated physics and to attempt to explain the formation of 1½ gallons of oil per ton of sediments in an area six times that of an oil pool, or if that seems to be too difficult, to form ½ gallon per ton of sediments in an area eighteen times the size of the pool into which it collects by simple gravitative adjustment.

Turning to Rich's second paper, we find seeming agreement among Rich, Gardner, Wilson, and the present writer on several points, of which the most

[1] W. V. Howard and W. W. Love, "Some Properties of Limestone as a Reservoir Rock," *Econ. Geol.*, Vol. 25, No. 7 (November, 1930), pp. 720-36.

[2] *Sci. Amer.* (October, 1931), p. 262.

important is that neither the Chattanooga nor the Cherokee shales form a source of the oil in the Granite ridge pools.

Rich's critics seem, however, to feel that Rich's alternative is not the only one and that there is a fourth possibility, namely a local source not already mentioned.

If we examine Rich's ideas of oil generation, we find that "the quantity of oil which would be produced by the devolatilization of the rocks in southeastern Oklahoma where carbon ratios were raised must have been very great" (p. 1445). To this one might reply, "Was any oil formed?"

However, if we admit that oil can be formed by metamorphism, how did the oil work its way through other metamorphosed rocks which are made dense by this process and head for the less highly metamorphosed carriers—or "Wilcox" sand carrier? It is obviously impossible for continuous porosity to be developed in a limestone surface as a result of weathering on any scale such as Rich postulates.

It seems as if the following hypothesis might more readily explain the occurrence of oil in the Granite ridge pools.

1. "The rocks beneath the Pennsylvanian were uplifted and bevelled before the Pennsylvanian was deposited" (Rich, p. 1440).

2. The bevelled edges of these rocks were made porous, or their porosity was increased, by weathering at this time.

3. When the area was submerged there was a considerable accumulation of organic matter on the sea floor and this organic matter was able to enter the porous rocks in some form—either as living or dead organisms or as decomposition products of these organisms.

4. At some later time when burial was complete there was a closed system with little or no circulation and in this system the organic matter was converted into oil and rose into the higher parts of the structure unless blocked by overlying material or by impervious zones of the older formations.

Thus the oil was post-Mississippian in age, but formed in the older rocks relatively near the locus of its present accumulation.

The writer freely admits that the chemistry of the reactions assumed in his hypothesis is not yet known, but neither is the chemistry of oil formation by metamorphism. Moreover, the writer's hypothesis does not involve the extremely complicated physics required by the long-distance migration hypothesis and the geological difficulties seem, also, to be very much less overwhelming.

W. V. HOWARD

URBANA, ILLINOIS
December 30, 1931

AUTHOR'S REPLY

I have hesitated to use the space required for a detailed reply to Howard's discussion of my recent papers because it seems to me that several of Howard's criticisms are irrelevant, others rest on his reading into the papers meanings which were not intended, and most of the remainder seem to have arisen from

his failure to think through the physical and geological aspects of the problem. It may be, however, that the original papers were not entirely clear and that a further discussion will serve a useful purpose.

For the sake of brevity, the paragraphs of Howard's discussion are referred to by number.

Paragraph 4. Unquestionably, a moderate thickness of bituminous "source" sediments, if distilled, is adequate to furnish the oil of our pools, but there is another interesting aspect of the problem. If such sediments are present and have yielded oil at the rate suggested by Howard, a pertinent question is, "What became of the great quantities of oil that would have been produced?" Let us grant, for example, that the oil in the Oklahoma City pool, which has an area of approximately 15 square miles, came from an area six times as large, or 90 square miles. Generation of oil at the same rate in a circular area having a radius equal to the distance to the nearest large pool—40 miles —would have produced enough oil to have filled 55 pools as large as Oklahoma City. Where is it? Are we not here forced either to concede extensive migration and segregation from a rather "lean" source or to make the gratuitous assumption of especially rich "source" materials in the immediate vicinity of the pools?

The arguments suggesting that the Oklahoma City pool did not come from a local source, either above or below the reservior, have been given in the Granite ridge paper.[1]

Paragraph 6. The question of the artesian outlet was not forgotten (page 918 of the carrier-bed paper).[2] It should, perhaps, be emphasized that the outlets of an artesian circulation may not be conspicuous at the surface, especially where upward leakage through the roof is an important factor. The very facts of artesian conditions and the down-dip penetration of surface waters indicate artesian circulation now or in the past. Whether the circulation is now active may or may not be significant in connection with oil migration. Earlier circulations are equally important.

Paragraph 8. It seems obvious that an artesian circulation must be affected by any conditions which increase the mobility of the circulating fluid throughout a large part of its course. The rate of fluid movement caused by a specified artesian head must be noticeably greater (because the total friction is less) if a large part of the path of flow is in a deep zone of high mobility than if all of the path is in a surface zone of lesser mobility. Further, the increased rate of artesian circulation is only one of the ways in which increased mobility affects oil migration. It affects migration in another way through the greater ease with which the fluids can move through the rock pores and through small fissures, and it makes movement possible through openings smaller, and under pressure differences lower, than would otherwise be required. In so far as oil migration may be caused by buoyancy, the increased mobility at depth is especially important.

[1]John L. Rich, "Function of Carrier Beds in Long-Distance Migration of Oil," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, No. 8 (August, 1931), pp. 911-24.

[2]John L. Rich, "Source and Date of Accumulation of Oil in Granite Ridge Pools of Kansas and Oklahoma," *op. cit.*, Vol. 15, No. 12 (December, 1931), pp. 1431-52.

The last sentence of paragraph 8 obviously is based on a misunderstanding. Howard is assuming velocities far greater than any contemplated by advocates of the hydraulic theory.

Paragraph 9. Another misunderstanding seems to have called forth paragraph 9. One of the current theories for the origin and initial migration of oil (of which, by the way, I am very skeptical) is that oil is deposited with the sediments or is generated in them, soon after deposition, by bacterial agencies, and is then squeezed out, along with water, into the more porous and less compactible sandy beds as the sediments compact. This mode of entrance of oil into the carrier bed was mentioned as one possibility (paragraphs 4 and 5, page 916 of the carrier-bed paper). How Howard interprets this to mean the conversion of solid hydrocarbons into oil by compaction, I can not imagine.

Paragraph 10. Before any conclusions are drawn on the basis of Howard's hypothesis for the formation of grahamite dikes, the correctness of that hypothesis should be established. Even if we grant that the walls of a fissure do absorb some of the lighter constituents of an oil, leaving a residue lining the walls, would not this lining seriously interfere with further absorption? Many of the grahamite dikes fill fissures several feet wide. Even granting Howard's hypothesis, can it be proved, or is it probable, that large quantities of oil did not pass through such fissures before the walls could absorb enough oil to close them? What of the numerous occurrences of oil in fissures?

Paragraphs 11-14. In connection with the criticisms expressed in paragraphs 11-14, it may be worth while to supplement the written argument in the carrier-bed paper by generalized sketches (Fig. 1) illustrating the fluid circulation there described and its relation to the trapping of oil. In studying the sketches, it should be borne in mind, as was carefully pointed out in the original paper, that the fluids in the lower beds are assumed to have a pressure

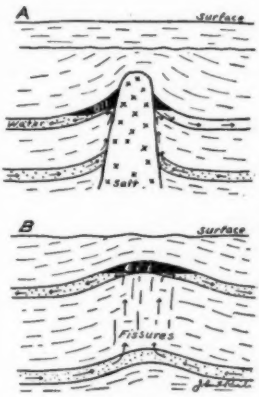

FIG. 1.—Sketches of salt dome and anticline showing circulation of fluids (water and oil) through fissures from lower to higher bed and segregation and trapping of oil in higher bed. In either anticlines or salt domes all gradations may be expected from those where fluid reaches surface in vicinity of "structure" to those where all reach surface as springs and seepages.

in excess of the simple hydrostatic pressure corresponding with the depth. How such excess pressure might be acquired was explained in the original paper.

Paragraphs 17 and 18. In regard to metamorphism, I refer to an earlier paper,[1] careful study of which should make clear that there is no necessity for oil to work its way out through rocks already metamorphosed. The conditions which cause the metamorphism are believed to generate and drive out the oil as one of the earliest stages of the process. From the area of most extreme metamorphism there should be every gradation outward to areas where there has been no metamorphism. As an area of metamorphism expands, the oil and gas should continually be driven out ahead and such as can not escape might be destroyed.

In connection with the last sentence of paragraph 18, a visit to the cave regions of southern Missouri or Kentucky and to the springs which issue from the Edwards limestone along the Balcones fault of Texas is recommended.

JOHN L. RICH

UNIVERSITY OF CINCINNATI
CINCINNATI, OHIO
February 13, 1932

[1] John L. Rich, "Generation of Oil by Geologic Distillation during Mountain Building," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 11, No. 11 (November, 1927), pp. 1139-49.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 16, NO. 3 (MARCH, 1932), PP. 267-270

REVIEWS AND NEW PUBLICATIONS

"Fallas y Petróleo en la Antigua Zona de Reserva Fiscal de Cinco Mil Hectáreas de Comodoro Rivadavia" (Faults and Petroleum in the Antigua Zone of the Federal Reserve of Five Thousand Hectares). By ENRIQUE FOSSA-MANCINI. *Boletin de Informaciones Petrolíferas*, Vol. 8, No. 84 (Buenos Aires, August, 1931), pp. 1-21; 8 figs.

After four years' work, Fossa-Mancini and his staff are able to demonstrate that the structure of the Government Reserve at Comodoro Rivadavia is not that of an elongate anticline as indicated by Windhausen in 1924, or a series of reflected buried hills as Bonarelli believed in 1926, but a large, broad, gentle east-west anticline 3 miles wide with an original structural relief of unknown amount which has been broken into complicated fault blocks. The central part of the anticline, a belt more than a mile wide, collapsed and the bounding faults have displacements ranging from 100 to 240 feet.

The oil in the petroliferous zone evidently accumulated in a series of lenticular sands in the large anticline, prior to the faulting, and migrated again after the faulting. Brecciation along the faults produced especially favorable reservoirs and the best wells are found near the faults. The poorest wells are found in the central low area and the largest wells, with initial production of 3,000 barrels a day, north of this area.

SIDNEY POWERS

TULSA, OKLAHOMA
January 16, 1932

Stream Sculpture on the Atlantic Slope, a Study in the Evolution of Appalachian Rivers. By DOUGLAS JOHNSON. (Columbia University Press, New York, 1931.) 142 pp.

This, the latest work on physiogeography by Professor Johnson, is a masterful treatise on erosion which can be read with profit by any geologist and, especially, by a petroleum geologist in the Mid-Continent region who is trying to decipher structure in beds deposited on peneplains such as those which existed formerly in the Appalachians.

SIDNEY POWERS

TULSA, OKLAHOMA
February 1, 1932

"The Older Appalachians of the South." By FRANK J. WRIGHT. *Jour. Sci. Lab.*, Vol. 26, pp. 143-269; *Denison University Bull.*, Vol. 31 (1931).

This study of physiogeography, with its 37 photographs, was awarded the A. Creasy Morrison prize in natural science for 1931 by The New York

Academy of Science. It is, unfortunately, not accompanied by a map or by sections. This physiogeographic history of these mountains has an important bearing on that of the Coastal Plain on the south in which oil is being sought.

SIDNEY POWERS

TULSA, OKLAHOMA
February 1, 1932

"Jurassic History of North America: Its Bearing on the Development of Continental Structure." By C. H. CRICKMAY. *Proc. Amer. Phil. Soc.*, Vol. 70 (1931), pp. 15-102.

This excellent monograph on Jurassic paleogeography, volcanism, and orogeny is accompanied by 14 paleogeographic maps and an extensive bibliography. Stratigraphic sections and type fossils for California are from personal studies, and for other areas are from the literature. New names are given for several land areas.

SIDNEY POWERS

TULSA, OKLAHOMA
February 1, 1932

Smithsonian Scientific Series. Edited by CHARLES GREELEY ABBOT. Smithsonian Institution, Washington, D. C. Vols. 1-11 completed, 1931; Vol. 12 in press, 1932. Illus. Approx. 9½ × 7 inches. More than 4,000 pp. Price, cloth, $180.00; de luxe, $500.00.

The Smithsonian Scientific Series is a twelve-volume collection of books concerning a variety of phases of the natural sciences. It may be classified as a group of academic narratives rather than as a series of highly technical dissertations. The work is a great credit to Charles Greeley Abbot, who organized the series and procured the collaboration of eminent authorities for the subjects discussed.

Much of the editorial work of the Smithsonian Institution has been disseminated by free distribution, but the publication here reviewed has involved such a tremendous amount of labor and expense that of necessity it has been issued as an exclusive publication. The entire resources of the Institution have been poured into the twelve-volume series in order to mold a pattern not only scientifically accurate but intensely interesting to laymen and technologists alike. The symposium does not follow a mathematical formula showing the development of the planetary system and the progress of life as we know it, but rather it reveals a scintillating display of the high lights of these processes.

Vol. 1 (330 pp.). Webster P. True sets forth the history, aims, and activities of the Smithsonian Institution. He begins with the time when James Smithson, an Englishman, who never saw America, bequeathed his choice collection of gems and minerals to form the nucleus around which Congress later constructed the Smithsonian Institution. He then describes the period when the institution encouraged and financed the work of struggling science. And finally he shows the development of the present policy, wherein its efforts to

broadcast scientific achievement and to foster research have led to a greatly diversified program.

Vol. 2 (322 pp.). Mankind's first god was the sun; its chief vitalizer is the sun; therefore, it is eminently fitting that the second volume of the series should be devoted to the consideration of this star, which was carefully studied by C. G. Abbot. The discussion of aboriginal investigations of the sun is brief, as that subject has been treated often. Greater emphasis is laid upon the effects of the sun on the earth and other planets. The instruments and methods used in this investigation are carefully described and the sun's habits thoroughly catalogued.

Vol. 3 (331 pp.). Following the study of the sun comes a dissertation on meteorites by G. P. Merrill and W. F. Foshag. The second part of the volume consists of a story of gems and gem minerals. The cuts and color plates in this volume are unusually attractive.

Vol. 4 (309 pp.). R. A. Palmer gives a very interesting account of the American Indians north of Mexico, recounting their probable origin, or at least their connection with the Asiatic aborigines, noting their diversification to Indians of the snows, of the plains, of the coasts, and of the mountains. There is an interesting chapter on their myths and legends and the volume closes with a sympathetic tribute to the Indian characters in history.

Vol. 5 (362 pp.). The insect pests of man are described and their ways and means of living interestingly told by R. E. Snodgrass in this volume.

Vol. 6 (362 pp.). This will probably be a very popular book, because it deals with wild animals in and out of the zoo. Most of the animals are intimately described, both in their natural haunts and in their reconstructed homes in the zoo. The wealth of illustration is taken from photographs by the author, William M. Mann, from files of the zoölogical parks and from some excellent artist's sketches by Benson B. Moore.

Vol. 7 (375 pp.). The evolution of man, particularly in the later stages, is carefully set out in Volume 7, entitled "Man from the Farthest Past." The volume is a coöperative effort by C. W. Bishop, C. G. Abbot, and Aleš Hrdlička. The distinction between man's physical development and his progress in civilization have been carefully maintained. Unlike most discussions on this subject, the story of man's physical development is carried from the recent to the remote past, but his conquest of the resources of nature are traced in their probable order of occurrence.

Vol. 8 (373 pp.). This volume again carries the reader into the remote past in its detailed description of cold-blooded vertebrates. It is co-written by C. W. Gilmore, I. M. Cochran, and S. F. Hildebrand. It is divided into three parts, namely, the fishes, the amphibians, and the reptiles. The illustrations, consisting of photographs, colored plates, and sketches of reconstructed animals, are most noteworthy.

Vol. 9 (389 pp.). This volume, which treats of the warm-blooded vertebrates, is a worthy companion to Volume 8. Herein are described the birds, by Alex Wetmore, and the mammals, by Garett S. Milles, Jr., and James W. Gidley. Wetmore's task of constructing a cross section of the 25,000 different kinds of birds, both fossil and existent, has been adroitly handled in the compass of one-half volume. In view of the limitations imposed by the lack of

space, the mammals are given a rapid review, emphasis being laid upon the more interesting varieties, both living and extinct.

Vol. 10 (365 pp.). The geological profession will find Volume 10, entitled "Shelled Vertebrates of the Past and Present," intensely interesting. Its opening chapters, covering the field of historical geology, have been carefully handled by R. S. Bassler and Charles E. Resser. Part 2 deals with crustaceans and is written by Waldo L. Schmidt. Part 3 describes the mollusks and is written by Paul Bartsch. The volume is remarkably illustrated, particularly with the colored plates depicting various forms of marine life.[1] The reconstruction of past life from paleontological data is intensely interesting and gives the conviction of approaching true conditions.

Vol. 11 (390 pp.). This volume is a symposium on old and new plant lore. A general picture is given of the life processes, the developments of plants, and their systematic study. The remainder of the volume is devoted largely to plants of the sea, grasses, desert vegetation, and the development of maize by the American Indian.

Vol. 12. This volume, which is in press, is entitled "Mankind in China," by John E. Lodge.

BRUCE H. HARLTON
HOWARD E. ROTHROCK

TULSA, OKLAHOMA
February 11, 1932

[1]Especially Plate 32, which shows (when in a dark room) the true colors and natural phosphorescent beauty of luminous crustaceans much as they appear in nature.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 16, NO. 3 (MARCH, 1932), PP. 271-326

THE ASSOCIATION ROUND TABLE

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election, but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to J. P. D. Hull, business manager, Box 1852, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

FOR ACTIVE MEMBERSHIP

Helmuth Albrecht, Volpriehausen, Hannover, Germany
Walter Kauenhowen, Hans Stille, Wilhelm Wunsdorf

Ralph Emery Esary, Bloomington, Ind.
J. J. Galloway, Glenn G. Bartle, J. W. Beede

Chalmers Van Anglen Pittman, Dallas, Tex.
L. Murray Neumann, M. A. Dresser, Bela Hubbard

Harold Scott Thomas, Oklahoma City, Okla.
Luther H. White, James H. Gardner, T. E. Weirich

FOR ASSOCIATE MEMBERSHIP

Carlton Gallaher Dinsmoor, Moran, Tex.
Worth W. McDonald, Joseph H. Markley, Jr., J. J. Maucini

Arthur Albert Wedel, Van, Tex.
R. A. Liddle, H. Ries, C. M. Nevin

FOR TRANSFER TO ACTIVE MEMBERSHIP

Raymond Arthur Broomfield, Jr., Los Angeles, Calif.
R. W. Sherman, R. D. Reed, E. B. Noble

Clarence E. Hamilton, Norman, Okla.
Hubert E. Bale, Glenn Grimes, Robert M. Whiteside

Joe Lawton, Pawhuska, Okla.
Marcus A. Hanna, H. M. Bayer, C. N. Housh

FINANCIAL STATEMENT, 1931

EXECUTIVE COMMITTEE
THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
Tulsa, Oklahoma

GENTLEMEN:

We have made an audit of the accounts and records of The American Association of Petroleum Geologists for the year ended December 31, 1931, and, as a result thereof, submit the following exhibits.

Exhibit A Statement of Financial Condition as at December 31, 1931

Exhibit B Statement of Income and Profit and Loss for the Year Ended December 31, 1931

Exhibit C Analysis of Expenses for the Year Ended December 31, 1931

Inventories of printed matter are stated at cost, after writing off publications on hand in excess of possible requirements, as authorized by the executive committee.

Bonds and securities have been adjusted to market value as at December 31, 1931, and accounts receivable from members have been written down $2,500.00 in accordance with instructions of the executive committee.

In our opinion, the accompanying statement of financial condition and relative statements of income and expenses correctly set forth the financial condition of The American Association of Petroleum Geologists as at December 31, 1931, and the results of its operations for the year ended at that date.

Respectfully submitted

(Signed) W. O. LIGON AND COMPANY
Certified public accountants

TULSA, OKLAHOMA
February 11, 1932

EXHIBIT A

EXHIBIT A

STATEMENT OF FINANCIAL CONDITION AS AT DECEMBER 31, 1931

ASSETS

	Total	*General Fund*	*Publication Fund*	*Research Fund*
CURRENT ASSETS				
Cash in Banks				
First National Bank and Trust Company	$ 7,121.55	$ 6,461.30	$ 660.25	
National Bank of Commerce	59.10	59.10		
Irving Trust Company	1,025.17	1,025.17		
Accounts Receivable				
Members (Less Reserve for Doubtful Accts. $2,500)	1,690.00	1,690.00		
Advertising	581.00	581.00		
Printed Matter	812.26	493.96	318.30	
Inventory	20,740.82	19,450.83	1,289.99	
Accrued Interest Receivable	590.53	457.87	109.62	23.04
TOTAL CURRENT ASSETS	$32,620.43	$30,219.23	$2,378.16	$ 23.04
INVESTMENTS				
Bonds and Savings Certificates at Market Value	28,410.64	18,728.24	8,752.95	929.45
Life Membership Investment Fund	539.94	539.94		
TOTAL INVESTMENTS	$28,950.58	$19,268.18	$ 8,752.95	$ 929.45
FIXED ASSETS				
Furniture and Fixtures	3,294.29	3,294.29		
Less—Reserve for Depreciation	1,183.33	1,183.33		
NET FIXED ASSETS	$ 2,110.96	$2,110.96		
INTERFUND BALANCES*		−2,262.88	2,262.88	
PREPAID AND DEFERRED CHARGES				
Prepaid Insurance	88.58	88.58		
Prepaid Expense Oklahoma City 1932 Meeting	9.54	9.54		
Preliminary Costs on Structure Volume III	1.98		1.98	
TOTAL PREPAID AND DEFERRED CHARGES	$ 100.10	$ 98.12	$ 1.98	
TOTAL ASSETS	$63,782.07	$49,433.61	$13,395.97	$ 952.49

*Convention Receipts $3,930.00
Deduct Convention Expenses 1,797.47
Net Convention Receipts $2,132.53
Sale of Continental Drift and Structure Volumes in General Fund Bank Account December 31, 1931 ..... 130.35
$2,262.88

LIABILITIES

	Total	*General Fund*	*Publication Fund*	*Research Fund*
CURRENT LIABILITIES				
Accounts Payable	$ 2,260.78	$ 2,260.78		
Society of Economic Paleontologists and Mineralogists	18.00	18.00		
TOTAL CURRENT LIABILITIES	$ 2,278.78	$ 2,278.78		
DEFERRED INCOME				
Active Membership Dues—1932	2,651.00	2,651.00		
Associate Membership Dues—1932	460.00	460.00		
Subscriptions—1932	1,303.35	1,303.35		
Payments for Bound Volume XV	340.00	340.00		
TOTAL DEFERRED INCOME	$ 4,754.35	$ 4,754.35		
SURPLUS				
Balance December 31, 1930	62,991.17	46,752.45	15,541.30	697.42
Adjustments				
1929 and 1930 Membership Dues Written off	−665.00	−665.00		
Adjusting Investments to Market Value	−13,413.75	−9,195.70	−3,915.55	−302.50
To Transfer Inventory of Structure Volume II, to General Fund		3,166.22*	−3,166.22	
ADJUSTED BALANCE	$48,912.42	$40,057.97	$ 8,459.53	$394.92
Net Profits for the Year Ended December 31, 1931, per Exhibit B	7,836.52	2,342.51	4,936.44	557.57
BALANCE DECEMBER 31, 1931	$56,748.94	$42,400.48	$13,395.97	$952.49
TOTAL LIABILITIES	$63,782.07	$49,433.61	$13,395.97	$952.49

*August 31, 1931.

EXHIBIT B

STATEMENT OF INCOME FOR THE YEAR ENDED DECEMBER 31, 1931

GENERAL FUND			
GROSS EARNINGS			
Dues			
Active Memberships	$28,952.50		
Associate Memberships	6,730.00	$35,682.50	
Sale of Bulletins			
Subscriptions	$ 3,998.90		
Bound Volumes	2,648.83		
Back Numbers and Separates	873.84		
Indexes	62.72		
Advertising—Less Commissions and Discounts	4,780.90	12,365.19	
Other Sales			
Alberta Symposium	$ 313.67		
Geophysics Symposium	169.08		
Structure of Typical American Oil Fields, Volume II	476.01	958.76	
GROSS EARNINGS			$49,006.4
OPERATING COSTS			
Cost of Bulletins Sold			
Inventory December 31, 1930	$15,665.69		
Transferred from Publication Fund	3,166.22		
Expenditures—Exhibit C	33,129.01		
TOTAL	$51,960.92		
Inventory December 31, 1931	19,450.83	$32,510.09	
General Expense—Exhibit C		16,088.40	
TOTAL OPERATING COSTS			$48,598.4
OPERATING INCOME			$ 407.9
OTHER INCOME			
Interest on Investments		$ 1,726.12	
Profit on Sale of Bond		81.75	
Sundry		126.68	
TOTAL OTHER INCOME—GENERAL FUND			$ 1,934.4
NET INCOME—GENERAL FUND			$ 2,342.3
PUBLICATION FUND			
SALES			
Structure of Typical American Oil Fields, Volume I		$ 902.65	
Structure of Typical American Oil Fields, Volume II		680.37	
Theory of Continental Drift		318.30	
TOTAL SALES		$ 1,901.32	
COST OF SALES			
Inventory December 31, 1930	$ 5,455.36		
Inventory December 31, 1931	1,289.99		
Remainder	$ 4,165.37		
Transferred to General Fund	3,166.22		
Cost of Publications Sold	$ 999.15		
Sundry Expenses	19.82		
COST OF SALES		$ 1,018.97	
NET PROFIT		$ 882.35	
OTHER INCOME			
Convention Receipts	$ 3,930.00		
Deduct Expenses	1,797.47	$ 2,132.53	
Donations		1,325.00	
Interest on Investments		584.80	
Miscellaneous		11.76	
INCOME FROM PUBLICATION FUND			$ 4,936.4
RESEARCH FUND			
Donations		$ 500.00	
Interest on Investments		57.57	
INCOME FROM RESEARCH FUND			$ 557.5
NET INCOME TO SURPLUS			$ 7,836.2

EXHIBIT C

ANALYSIS OF EXPENSES FOR THE YEAR ENDED DECEMBER 31, 1931

	Totals	*Publication Fund*	*General Fund*			
			Bulletins	*Alberta Symposium*	*Geophysics Symposium*	*General*
SALARIES						
Manager's Salary	$ 6,833.35		$ 3,416.68	$38.87	$ 20.05	$ 3,357.75
Editorial Secretary	4,054.52		4,054.52			
Clerical Salaries	5,430.00		915.00			4,515.00
TOTAL SALARIES	$16,317.87		$ 8,386.20	$ 38.87	$ 20.05	$ 7,872.75
BULLETINS						
Cost of Printing Bulletins	$19,425.74		$19,425.74			
Cost of Printing Separates	613.41		613.41			
Cost of Engraving	1,561.60		1,561.60			
Binding of Volume XIV	1,629.00		1,629.00			
Purchase of Back Numbers	140.75		140.75			
Sundry Costs	13.00		13.00			
TOTAL BULLETINS	$23,383.50		$23,383.50			
ALBERTA SYMPOSIUM						
Printing and Binding	$ 348.75			$348.75		
GEOPHYSICS SYMPOSIUM						
Printing	$ 162.58				$162.58	
OFFICE EXPENSE						
Office Rent	$ 300.00					$ 300.00
Printing and Stationery	846.79					846.79
Postage	1,001.57			40.00		961.57
Office Supplies	343.64					343.64
Telephone and Telegraph	235.94					235.94
Depreciation of Office Furniture and Fixtures	323.56					323.56
Stencil Corrections and Mailing	749.06		$ 749.06			
TOTAL OFFICE EXPENSE	$ 3,800.56		$ 749.06	$ 40.00		$ 3,011.50
OTHER EXPENSES						
Exchanges and Refunds	$ 57.36					$ 57.36
Executive Expense	16.30					16.30
Traveling Expense	58.64					58.64
Audit Expense	373.41					373.41
Freight, et cetera	10.08					10.08
Legal Services	154.74					154.74
Insurance	238.49					238.49
Advertising Special Publications	33.60					33.60
Donations to Society of Economic Paleontologists and Mineralogists	454.00					454.00
Donations to 1933 International Congress	500.00					500.00
Custodian's Fee—Irving Trust Co.	38.14					38.14
Expense Incident to 1931 G. S. A. Meeting	21.61					21.61
Bad Debts	3,238.00					3,238.00
Research Program	9.78					9.78
Miscellaneous Publication Fund Expense	19.82	$ 19.82				
TOTAL OTHER EXPENSES	$ 5,223.97	$ 19.82				$ 5,204.15
TOTAL EXPENSES—TO EXHIBIT B	$49,237.23	$ 19.82	$32,518.76	$427.62	$182.63	$16,088.40

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
MEMBERSHIP LIST

March 1, 1932

HONORARY MEMBERS

The executive committee may from time to time elect as honorary members persons who have contributed distinguished service to the cause of petroleum geology. Honorary members shall not be required to pay dues.—*Sec. 6, Article III, of the Constitution.*

LIFE MEMBERS

The executive committee may grant life membership to members who have paid their dues and are otherwise qualified.—*Sec. 2, Article III, of the Constitution.*

On the payment of three hundred dollars ($300.00) any member in good standing shall be declared a life member and thereafter shall not be required to pay annual dues.—*Sec. 3, Article I, of the By-Laws.*

MEMBERS

Any person engaged in the work of petroleum geology or in research pertaining to petroleum geology or technology is eligible to active membership, provided he is a graduate of an institution of collegiate standing, in which institution he has done his major work in geology, or in sciences fundamental to petroleum geology, and in addition has had the equivalent of three years' experience in petroleum geology or in the application of these other sciences to petroleum geology or to research in petroleum geology or technology; and provided further that in the case of an applicant for membership who has not had the required collegiate or university training, but whose standing in the profession is well recognized, he shall be admitted to membership when his application shall have been favorably and unanimously acted upon by the executive committee; and provided further that these requirements shall not be construed to exclude teachers and research workers in recognized institutions whose work is of such character as in the opinion of the executive committee shall qualify them for membership.

Active members alone shall be known as members.—*Sec. 1, Article III, of the Constitution.*

ASSOCIATES

Any person having completed as much as thirty hours of geology (an hour shall here be interpreted as meaning as much as sixteen recitation or lecture periods of one hour each, or the equivalent in laboratory) in a reputable institution of collegiate or university standing, or who has done field work equivalent to this, is eligible to associate membership, provided at the time of his application for membership he shall be engaged in geological studies in an institution of collegiate or university standing, or shall be engaged in petroleum geology; and any person who is a graduate of an institution of collegiate standing, in which he has done his major work in sciences fundamental to petroleum geology or petroleum technology, and who has the equivalent of one year's experience in the application of his science to the study of petroleum geology, shall be eligible to associate membership, provided at the time of his application for membership he shall be engaged in investigation in the broader subject of petroleum geology and technology.

Associate members shall be known as associates.

Associates shall enjoy all the privileges of membership in the Association, save that they shall not hold office, sign applications for membership, or vote; neither shall they have the privilege of advertising their affiliation with the Association in professional cards or professional reports or otherwise.—*Sec. 3, Article III, of the Constitution.*

HONORARY MEMBERS

(**Deceased)

Decker, Charles E., 508 Chautauqua Ave., Norman, Okla.
**Dumble, E. T.
Goodrich, Harold B., 1628 S. Cincinnati, Tulsa, Okla.
Hill, Robert T., Hotel Commodore, Los Angeles, Calif.
Orcutt, W. W., Union Oil Company Bldg., Los Angeles, Calif.
**Salisbury, R. D.
Smith, George Otis, Federal Power Commission, Interior Bldg., Washington, D. C.
**Udden, Johan August
**von Höfer, Hans Hofrat
White, David, U. S. Geological Survey, Washington, D. C.
**White, I. C.

COMPLETE LIST OF MEMBERS, ASSOCIATES, HONORARY MEMBERS, AND LIFE MEMBERS

Honorary	6
Life	2
Members	1,917
Associates	633
Total	2,558

||Abbott, John L., Texas Pacific Coal & Oil Co., Box 511, Carlsbad, N. Mexico...'27
||Abell, George T., Midland, Tex.....'29
Abraham, Arthur W., Box 1466, Bakersfield, Calif.....'30
Abrahamson, H., 1111 W. Fifth St., Fort Worth, Tex.....'18
Abruns, Harry W., 259 S. Harvard St., Los Angeles, Calif.....'27
||Absher, Kenneth B., Box 543, Wichita, Kan.....'25
Absher, William F., Empire Gas & Fuel Co., Geological Dept., Bartlesville, Okla..'20
Ackers, A. L., Stanolind Oil & Gas Co., Box 257, San Angelo, Tex.....'25
||Adams, Elmo W., 2524 Orella St., Santa Barbara, Calif.....'30
Adams, Frank C., The Texas Co., Houston, Tex.....'27
Adams, George I., University of Alabama, Tuscaloosa, Ala.....'21
Adams, H. H., 1937 Chatbourn Court, Fort Worth, Tex.....'19
Adams, John Emery, Drawer R, Midland, Tex.....'29
Adams, Lowell A., 324 S. Rampart Blvd., Los Angeles, Calif.....'31
||Adams, Theodore F., Kappa Sigma House, Golden, Colo.....'29
Adams, W. C., Deep Rock Oil Corp., Atlas Life Bldg., Tulsa, Okla.....'24
Addison, Carl C., 515 Lougheed Bldg., Calgary, Alta., Canada.....'30
Adkins, W. S., Bureau of Economic Geology, Univ. of Texas, Austin, Tex.....'20
Adler, Joseph L., 135 Agate St., Houghton, Mich.....'30
Aguerrevere, Pedro I., Sur 3, No. 94, Caracas, Venezuela, S. A.....'24
Aguerrevere, Santiago E., Sur 3, No. 94, Caracas, Venezuela, S. A.....'24
Aid, Herbert, Taylor Refg. Co., Taylor, Tex.....'28
Aimer, James D., Drawer 1731, Shreveport, La.....'26
Ainsworth, David, 604 N. Fountain Ave., Wichita, Kan.....'23
Ainsworth, William L., 301 N. Yale St., Wichita, Kan.....'21
Aitken, William E., St. George Hotel, Brooklyn, N. Y.....'32
Albertson, Maurice M., Box 1650, Dallas, Tex.....'20
||Alcorn, Avary Hunt, 435½ Queen Ann, San Antonio, Tex.....'32
Aldrich, G. Frank, 2024 Wilshire Blvd., Fort Worth, Tex.....'25
||Aldridge, Mort B., Ramsey Petr. Corp., 18th Floor Petroleum Bldg., Oklahoma City, Okla.....'27

*Honorary member. †Life member. ||Associate. Members are not marked. The year refers to date of election to the Association, not necessarily to class of membership.

||Alexander, A. E., 81 Perkins Hall, Harvard University, Cambridge, Mass. . . . . '31
Alexander, A. M., 704 Masonic Bldg., Bartlesville, Okla. . . . . '31
Allan, John Andrew, University of Alberta, Edmonton, Alta., Canada . . . . . '30
Allan, Thos. H., Box 362, Russell, Kan. . . . . '24
Allen, Bryant, Box 12, Laredo, Tex. . . . . '25
Allen, Devere F., 1205 Lowe St., Fort Worth, Tex. . . . . '29
Allen, Donald M., 1621 Keeler Ave., Bartlesville, Okla. . . . . '24
Allen, E. G., Box 1650, Dallas, Tex. . . . . '17
Allen, Walter J., Box 2203, Tulsa, Okla. . . . . '18
Allison, A. P., Box 81, Lufkin, Tex. . . . . '21
Althaus, H. E., Astra Romana, Campina, Roumania . . . . . '28
Ambrose, A. W., Empire Gas & Fuel Co., Bartlesville, Okla. . . . . '19
Ames, Edward W., Box 455, Marshall, Tex. . . . . '19
Ames, E. R., 228 Thorn St., Los Angeles, Calif. . . . . '24
Anderson, Amil A., Box 423, San Francisco, Calif. . . . . '22
Anderson, Carl B., 941 Kennedy Bldg., Tulsa, Okla. . . . . '19
Anderson, Frank M., 58 Hillcrest Road, Berkeley, Calif. . . . . '24
Anderson, G. E., 645 Lahoma, Norman, Okla. . . . . '24
Anderson, J. L., 2104 Rosedale St., Baltimore, Md. . . . . '29
Anderson, Lyman P., 1631 W. Twenty-Ninth St., Oklahoma City, Okla. . . . . '27
||Anderson, Richard S., Box 2022, Tulsa, Okla. . . . . '31
Anderson, Warren D., Box 832, San Angelo, Tex. . . . . '27
Andreen, Harry M., Box 2045, Tulsa, Okla. . . . . '27
||Andrews, Hugh, Stratford, Okla. . . . . '30
Andrews, Philip, 1675 Euclid Ave., Berkeley, Calif. . . . . '25
Andrews, Sylvan H., 421 Philcade Bldg., Tulsa, Okla. . . . . '20
||Angle, W. M., Box 731, Tyler, Tex. . . . . '30
Apfel, Earl T., Geol. Dept., Syracuse University, Syracuse, N. Y. . . . . '29
Applin, Paul L., 2200 Edwin Ave., Fort Worth, Tex. . . . . '19
Argabrite, William Graeme, Chandler, Okla. . . . . '28
||Arick, Millard B., Box 938, McCamey, Tex. . . . . '27
||Armor, Mildred V., 3711 Classen Blvd., Oklahoma City, Okla. . . . . '30
Armstrong, Harold K., Room 838, 727 W. Seventh St., Los Angeles, Calif. . . . . '27
Armstrong, J. M., Prairie Oil & Gas Co., Eastland, Tex. . . . . '18
Arnett, Clarence L., 301 S. Eighth St., Ponca City, Okla. . . . . '27
Arnold, Emmett L., 538 Mayo Bldg., Tulsa, Okla. . . . . '27
Arnold, Harry H., Jr., 602 W. Dewey St., Shawnee, Okla. . . . . '27
||Arnold, Henry C., Box 97, Earlsboro, Okla. . . . . '30
Arnold, Ralph, 1201 E. California St., Pasadena, Calif. . . . . '18
Aronson, Sam M., Atlantic Oil Prod. Co., 701 Magnolia Bldg., Dallas, Tex. . . . . '24
Artman, George W., 700 N. E. Fifteenth St., Oklahoma City, Okla. . . . . '25
||Atchison, J. Wilbur, Pure Oil Co., Box 1007, Fort Worth, Tex. . . . . '31
Athy, Lawrence F., Geophysical Division, Continental Oil Co., Ponca City, Okla. . '26
Atkinson, William H., 26th Floor Ramsey Tower, Oklahoma City, Okla. . . . . '22
Atwill, E. R., Box 552, Bakersfield, Calif. . . . . '31
Aurand, Harry A., 1350 Bellaire St., Denver, Colo. . . . . '26
Aurin, Fritz L., Southland Royalty Co., Ponca City, Okla. . . . . '17
Autry, Vernon E., Humble Oil & Refining Co., Box 1034, Wichita Falls, Tex. . . . . '26
Avery, C. Dwight, U. S. Geological Survey, 3240 Interior Bldg., Washington, D. C. . '28
||Ayers, Floyd M., Sabetha, Kan. . . . . '30

Bace, A. C., Stanolind Oil & Gas Co., Philcade Bldg., Tulsa, Okla. . . . . '24
Bacon, Charles S., Jr., Geology Dept., Riverside Junior College, Riverside, Calif. . . '29
Baden, M. W., Box 520, 201-202 Baden Bldg., Winfield, Kan. . . . . '21
Bagg, Rufus M., 16 Brokaw Place, Appleton, Wis. . . . . '27
||Bailey, Donald G., 1221 Subway Terminal Bldg., Los Angeles, Calif. . . . . '31
Bailey, James P., N. V. Ned. Pac. Petr. Mij., Prinsenstraat, hoek Stradhuisplein, Batavia, Java, D. E. I. . . . . '31

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||Bailey, Joe, 1201 E. Eleventh St., Winfield, Kan. '30
Bailey, Thomas L., Box 713, Ventura, Calif. '24
Bain, H. Foster, Copper & Brass Research Asso., 25 Broadway, New York, N. Y. '26
Baird, Chester A., Apartado 234, Venezuela Gulf Oil Co., Maracaibo, Venezuela, S. A. '21
Baker. Arthur A., U. S. Geological Survey, Washington, D. C. '30
Baker, Charles L., Bureau of Econ. Geology, University Station, Austin, Tex. '19
||Baker, Lara H., 542 Wall St., Shreveport, La. '29
Baker, Norval E., Room 1567, 26 Broadway, New York, N. Y. '27
Baker, Raymond F., The Texas Co., Geol. Dept., 135 E. Forty-Second St., New York, N. Y. '17
Baker, William A., Jr., Geol. Dept., Cia. de Petr. Mercedes, S. A., Apartado 269, Monterrey, N. L., Mexico '24
||Bakke, W. E., Geological Dept., North Penn Gas Co., Port Allegany, Pa. '28
Baldwin, E. B., Belleville, Austin County, Tex. '29
Baldwin, Harry L., Jr., 2600 Ramsey Tower, Oklahoma City, Okla. '22
Bale, Hubert E., 1130 W. Forty-First St., Oklahoma City, Okla. '24
Ball, Max W., 715 First Natl. Bank Bldg., Denver, Colo. '19
||Ballard, Andrew L., 1518 Alamo Natl. Bldg., San Antonio, Tex. '21
Ballard, James L., Drawer F, Houston, Tex. '25
||Ballard, William Norval, 219 Magnolia Bldg., Oklahoma City, Okla. '29
||Banks, Overton B., 2250 Neches St., Beaumont, Tex. '30
Banks, Thomas R., Magnolia Petroleum Co., 2110 Alamo Natl. Bldg., San Antonio, Tex. '27
Barbat, William F., Standard Oil Co., Taft, Calif. '28
Bard, Richards J , Wayne, Pa. '28
||Barksdale, J. D., 133 W. Gray St., Elmira, N. Y. '31
||Barling, Robert, 606 Milam Bldg., San Antonio, Tex. '27
Barlow, Victor, 121 N. Hill St., Los Angeles, Calif. '27
Barnes, Roy M., Continental Oil Co., 417 S. Hill St., Los Angeles, Calif. '24
||Barnes, Virgil E., 591 Ohio Ave., Chehalis, Wash. '31
Barnett, D. G., 1303 Rosario, Laredo, Tex. '25
||Barnett, J. A., 228 Centre St., Dallas, Tex. '28
||Barney, Arthur Y., Piney Oil & Gas Co., 1139 Milam Bldg., San Antonio, Tex. '30
Barnhart, Carl F., 723 E. Cypress, Altus, Okla. '29
Barnwell, George F., Ned. Kol. Petr. Mij., Weltevreden, Java, D. E. I. '28
||Barragy, Edward J., Rockwell, Iowa '31
Barret, William M., 2524 Fairfield Ave., Shreveport, La. '32
||Barrett, Albert F., Box 146, Parco, Wyo. '30
||Barrett, Claude L., Twin State Oil Co., Box 1501, Tulsa, Okla. '28
Barrett, Morris K., Box 181-A, Wheatridge, Colo. '27
Barrow, Geoffrey, 344 Robin Hood Lane, Hall Green, Birmingham, England '31
Barrow, Leonidas T., 3314 Chevy Chase, River Oaks, Houston, Tex. '22
Bartell, Laurence D., East Texas Refg. Co., Longview, Tex. '27
Barth, William A., Imperial Oil & Gas Products Co., Owensboro, Ky. '23
Bartle, Glenn G., Dept. of Geology, Indiana University, Bloomington, Ind. '27
||Bartle, Ronald L., 2112 N. Villa St., Oklahoma City, Okla. '28
Bartlett, C. Lothrop, Sun Oil Co., Beaumont, Tex. '28
Bartlett, Fred W., Box 1650, Dallas, Tex. '24
Barton, Donald C., Petroleum Bldg., Houston, Tex. '20
Barton, Louis A., Box 433. Shreveport, La. '20
Bartosh, Edmund J., 605 N. Bushnell Ave., Alhambra, Calif. '28
Bartram, John G., 2555 Clermont Ave., Denver, Colo. '17
||Bartram, Paul L., Box 176, Aspermont, Tex. '27
Barwick, John S., 510 S. Pearl, Paola, Kan. '24
Bass, N. W., U. S. Geological Survey, Wichita, Kan. '25
Bassett, Charles F., University of Michigan, 1526 University Museum, Ann Arbor, Mich. '28

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Bassler, Harvey, c/o Samuel Mosser, Myerstown, Pa. '28
Bastin, Edson S., Rosenwald Hall, University of Chicago, Chicago, Ill. '26
Bateman, Alan M., Yale University, Drawer C, Yale Station, New Haven, Conn. '20
||Bates, R. P., 404 Springer Bldg., Tulsa, Okla. '30
Bauer, C. Max, Box 61, Route 3, Boulder, Colo. '17
Bauermann, Max K. H., Carel van Bylandtlaan 30, The Hague, Holland '27
Bauernschmidt, A. J., Jr., Box 1236, Salt Lake City, Utah '27
Bauserman, E. V. H., 308 Federal Bldg., Dallas, Tex. '26
||Bay, Harry X., Cole Camp, Mo. '30
Bayer, H. M., Box 968, Midland, Tex. '25
||Bayle, Pierre, Caribbean Petr. Co., Maracaibo, Venezuela, S. A. '31
Beal, Carl H., 650 S. Grand Ave., Los Angeles, Calif. '19
||Bean, John M., Elwood, Nebr. '30
Bean, Ward C., Box 1162, Tulsa, Okla. '18
Beatty, Robert M., 945 W. Ninth St., Erie, Pa. '27
||Beck, August F., 1620 S. Troost St., Tulsa, Okla. '27
Beck, Elfred, Producers & Refiners Corp., Exchange Natl. Bank Bldg., Tulsa, Okla. '20
Beck, N. C., 1110 Electric Bldg., Fort Worth, Tex. '30
Beckelhymer, Roy L., Box 1141, Memphis, Tenn. '26
Becker, Clyde M., 224 S. Fourteenth St., Chickasha, Okla. '21
Beckstrom, R. C., 1620 S. Boston, Apt. 4, Tulsa, Okla. '30
Beckwith, H. T., 547 Subway Terminal Bldg., Los Angeles, Calif. '21
Beede, J. W., Route 1, Bloomington, Ind. '19
Beekly, Albert L., Box 2025, Tulsa, Okla. '19
Beers, Roland F., 30 Trapelo Road, Belmont, Mass. '31
Behre, Charles H., Jr., Dept. of Geology, Northwestern University, Evanston, Ill. '29
||Beilharz, Carl F., 820 Florida Ave., Chickasha, Okla. '27
Belknap, Ralph L., University of Michigan, Ann Arbor, Mich. '31
Bell, Alfred H., State Geological Survey, Urbana, Ill. '28
Bell, Harry Wesley, Lion Oil Refining Co., Exchange Bldg., El Dorado, Ark. '22
Bell, John, 31 Cottage Lane, Gamesley, Glossop, Derbyshire, England '24
Bell, Olin G., Box 548, Laredo, Tex. '20
Belluigi, Arnaldo, Via. Vitt. Em. 178, Parma, Italy '31
Belt, Ben C., 3451 Del Monte Drive, Houston, Tex. '19
||Benderoff, Vassili C., Box 464, Springfield, Colo. '27
Bending, Ralph E., 406 Orpheum Bldg., Wichita, Kan. '25
Benedum, Darwin, 414 W. Elsmere Pl., San Antonio, Tex. '27
Bennett, Clyde M., Magnolia Petr. Co., Dallas, Tex. '18
Benson, Dale L., Box 263, Tulsa, Okla. '25
||Benson, Don G., Box 383, Perry, Okla. '31
||Benson, Edmund T., State Geological Survey, Urbana, Ill. '31
||Benson, Floyd P., 515 E. Oklahoma, Blackwell, Okla. '31
Bentley, B. Howard, 708 San Angelo Natl. Bank Bldg., San Angelo, Tex. '30
Benton, Louis B., 1730 Sixth Ave., Fort Worth, Tex. '20
Bentz, Ivan V., 424 W. Twenty-Ninth St., Kearney, Nebr. '25
Berger, Walter R., 2532 Cockrell Ave., Fort Worth, Tex. '17
Bernard, W. E., Box 2044, Tulsa, Okla. '21
Bernoulli, W., 57 Sissacherstrasse, Basle, Switzerland '24
Berry, Hally L., Venezuelan Sun Ltd., Apartado 34, Maracaibo, Venezuela, S. A. '27
||Berry, Harry L., Box 836, Cushing, Okla. '30
||Berry, Jack J., Box 836, Cushing, Okla. '30
Berwald, W. B., U. S. Bureau of Mines, Bartlesville, Okla. '23
Best, J. Boyd, Houston Oil Co. of Tex., Box 1779, Houston, Tex. '21
Bevier, George M., 2106 Truxillo Ave., Houston, Tex. '21
Bickel, C. Russell, Shell Petr. Corp., Greenwich, Kan. '27
Bierman, Alfred C., Fain McGaha Oil Corp., 607 Hamilton Bldg., Wichita Falls, Tex. '19
Billingsley, J. E., 1108 Union Bldg., Charleston, W. Va. '30

*Honorary member. †Life member. ||Associate. Members are not marked. The year refers to date of election to the Association, not necessarily to class of membership.

||Bingham, Dwight H., Creole Petr. Corp., Caracas, Venezuela, S. A. '21
||Bingman, Neal J., Box 578, Midland, Tex. '30
Biraud, Francois, Iraq Petroleum Co., Ltd., Kirkuk, Iraq. '31
||Birdsong, P. M., 1522 Grand Ave., Fort Worth, Tex. '30
Birk, Ralph A., 811 City Natl. Bank Bldg., Wichita Falls, Tex. '20
Birkett, Donald S., 7 Eutropia Court, Louisville, Ky. '27
Birkhauser, Max, Box 345, Oilfields, Calif. '26
||Blackburn, Willis C., Humble Oil & Refg. Co., 204 Nixon Bldg., Corpus Christi, Tex. '28
Blackwelder, Eliot, Box N, Stanford University, Calif. '19
Blanchard, J. B., 1114 S. College Ave., Tyler, Tex. '31
Blanchard, W. Grant, Jr., 3609 Potomac, Dallas, Tex. '18
Blanpied, B. W., Box 673, Meridian, Miss. '23
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Gutzwiller, Otto, Bremgarten, Aargau, Switzerland '28

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Hager, Dorsey, Hotel Morck, Aberdeen, Wash. '19
Hager, Lee, 1521 Esperson Bldg., Houston, Tex. '18
Hagy, Lawrence R., 508 Amarillo Bldg., Amarillo, Tex. '25
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Harrell, Marshall A., 821 Milam Bldg., San Antonio, Tex. '27
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Helquist, G. A., Luteranskiy per. N 3, No. 3, Baku, U. S. S. R. '31
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Winchester, Dean E., 307-8 C. A. Johnson Bldg., Seventeenth & Glenarm Sts., Denver, Colo. '21
Wines, Donald Bradford, 733 E. Clinton St., Howell, Mich. '29
||Winfrey, Donald B., 719 Chautauqua Ave., Norman, Okla. '31
Winham, W. P., 1921 B St., Bakersfield, Calif. '28
||Winkler, Bruno Oscar, Dept. of Geology, Colorado School of Mines, Golden, Colo. '31
||Winkler, Hans, Sun Oil Co., R. 6, Longview, Tex. '31
Winn, W. E., 3240 Daniel St., Dallas, Tex. '31
Winsor, Owen A., Frederick, Okla. '25
Winston, William Bruce, Venezuela Gulf Oil Co., Apartado 234, Maracaibo, Venezuela, S. A. '31
Winter, Niles B., Box 817, San Angelo, Tex. '24
||Winterer, Edward V., 218 E. Hermosa St., Santa Maria, Calif. '27
Winton, Will M., Texas Christian University, Fort Worth, Tex. '20
Wissler, Stanley G., Union Oil Co. of Calif., Box F, Compton, Calif. '27
Wolf, Albert G., Texas Gulf Sulphur Co., 1009 Second Natl. Bank Bldg., Houston, Tex. '24
Wolff. Deane J., 404 Back Bay Blvd., Wichita, Kan. '23
||Wolters, Earl M., Humble Oil Co., Drawer D, Houston, Tex. '30
Wood, Flavius C., Jr., 1003 K St., N. W., Washington, D. C. '30
Wood, Fred E., Standard Oil Co. (Ind.), 910 S. Michigan Ave., Chicago, Ill. '24
||Wood, George R., 519 N. Franklin, Hampton, Iowa '30
Wood, James T., Jr., 2717 Fleur Drive, San Marino, Calif. '24
||Wood, J. Pendleton, 314 I. W. Hellman Bldg., Los Angeles, Calif. '27
Wood, Robert H., 430 Beacon Life Bldg., Tulsa, Okla. '20
Wood, Virgil O., 430 Beacon Life Bldg., Tulsa, Okla. '20
Woodford, Alfred O., Pomona College, Claremont, Calif. '24
Woodruff, E. G., 1611 S. Detroit, Tulsa, Okla. '19
Woods, E. Hazen, Superior Oil Co., 1104 Tower Petroleum Bldg., Dallas, Tex. '25
||Woods, Percy O., Humphreys Corp., Mt. Belvieu, Tex. '31
Woods, Sam H., Box 1501, Tulsa, Okla. '25
||Woodward, George E., Jr., Drawer F, Houston, Tex. '29
Woodward, Harold Robinson, Box 1103, Wichita, Kan. '25
||Woolfolk, Edward R., 502 C St., N. W., Ardmore, Okla. '28
Woolley, Glen C., 315 E. Dewey St., Wichita, Kan. '28
Woolnough, W. G., Dept. of Home Affairs, Canberra, F. C. T., Australia '29
Woolsey, E. V., Box 360, Luling, Tex. '20
||Worthington, K. Elizabeth, 1618 Milam Bldg., San Antonio, Tex. '30
Wosk, L. David, 341 F St., San Diego, Calif. '24
Wrather, William E., 4300 Overhill Drive, Dallas, Tex. '17
Wright, Andrew C., Box 610, Tyler, Tex. '20
Wright, A. P., 904 Petroleum Bldg., Tulsa, Okla. '22
Wright, Fay Linton, 6416 Lindenhurst Ave., Los Angeles, Calif. '27
Wright, Fred S., Box 24, Midland, Tex. '20
Wright, Harry F., Box 1993, Tulsa, Okla. '19
Wright, Hugh, 1008 Second Natl. Bank Bldg., Houston, Tex. '30
Wylie, James R., Jr., 2811 Grant Bldg., Pittsburgh, Pa. '21
Wyllie, B. K. N., Anglo-Persian Oil Co., Britannic House, Finsbury Circus, London, E. C. 2, England '27
Wyman, Everett, A., Box 995, Wichita, Kan. '24
Wynn, Warren H., Box 859, Shawnee, Okla. '26

Yager, Charles E., Box 1868, Fort Worth, Tex. '24
Yeager, Lloyd I., Empire Cos., 407 W-K-H Bldg., Wichita, Kan. '30
Yewell, P. R., Holcomb-Blanton Bldg., San Angelo, Tex. '26
Yoakam, Coler A., Box 1162, Oklahoma City, Okla. '22
Yoakam, Harlan H., 1422 Kansas, Woodward, Okla. '29
Young, Addison, 916 N. Haskell St., Dallas, Tex. '30

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||Young, Claude T., 410 S. Church St., Cordell, Okla. . . . . '27
||Young, Gerald D., Brock, Nebr. . . . . '29
||Young, Jackson S., 1110 N. Jefferson, Jackson, Miss. . . . . '28
Young, Karl E., 713 Esperson Bldg., Houston, Tex. . . . . '26
Young, Umberto, 201 N. La Pere, Beverly Hills, Calif. . . . . '28
||Youngmeyer, Ray, Amerada Petr. Corp., Box 707, Chickasha, Okla. . . . . '27
Youngs, L. J., 612 Orpheum Bldg., Wichita, Kan. . . . . '20
Younkman, Harry, 522-A W. Brady St., Tulsa, Okla. . . . . '21

Zavoico, Basil B., 501 Philtower, Tulsa, Okla. . . . . '25
Ziebold, William O., 1572 Virginia St., Charleston, W. Va. . . . . '29
||Zimerman, Sam, c/o Seismic Party, N. K. P. M., Batavia, Java, D. E. I. . . . . '31
Zimmerman, C. C., Drawer F, Houston, Tex. . . . . '31
Zimmerman, James Z., 511 Union Natl. Bank Bldg., Wichita, Kan. . . . . '22
Zoller, H. E., Shell Petr. Corp., Box 56, Kilgore, Tex. . . . . '25
Zoller, Lawrence J., Central Commercial Oil Co., Box 1928, Tulsa, Okla. . . . . '21
Zorichak, Joseph J., 3707 Osceola, Denver, Colo. . . . . '24
Zuber, Stanislav, Dlugosza 31, Lwow, Poland . . . . . '31

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BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
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Memorial

ELDRIDGE DOUGLAS PHILLIPS

Eldridge Douglas Phillips was fatally injured near Destrahan, Louisiana, on November 18, 1931, when his car was struck by a milk truck on a wet road while he was en route to his home in New Orleans.

Ed Phillips was born in Shreveport, Louisiana, December 8, 1894. After receiving his early schooling in Pineville, Louisiana, he attended Louisiana College, in the same town, from the fall of 1915 to the spring of 1917.

On July 3, 1917, he enlisted in the Fifth Regiment of the U. S. Marine Corps, and, after going overseas, he participated in several engagements, including Verdun, Aisne Defensive, Chateau Thierry, Aisne-Marne (Soissons), St. Mihiel, Meuse Argonne, the Meuse Argonne Offensive, and finally in the march of the Allied Armies to the Rhine. For bravery in action he was cited by both the American and French governments, the coveted Croix de Guerre being the most important. He was one of three men in his company who passed through every action without a scratch.

Subsequent to his discharge from the Marine Corps on August 13, 1919, he re-entered Louisiana College for the school year of 1919-1920. In 1920 he entered Baylor University, Waco, Texas, receiving his B. A. degree in June, 1921.

In 1922 he entered the employ of the Humble Oil and Refining Company as geologist, and during the remainder of that year and a part of the year 1923 he was engaged in field work in south Texas. In the summer of 1923 he was with the Kentucky State Geological Survey assisting Stuart Weller in areal mapping. In the fall of 1923 he entered the University of Chicago where he received his M. S. degree in geology the following spring. During the school year of 1924-1925 he was professor of geology at Baylor University, leaving that institution to re-enter the services of the Humble Oil and Refining Company on May 8, 1925.

During the succeeding six and a half years, his work as geologist for this company was confined to the Gulf Coast of Texas and Louisiana, where he did much pioneer work in Victoria, Goliad, and Bee counties, Texas, in a region which subsequently became productive of considerable oil. His work in Louisiana contributed materially to our knowledge of the occurence of salt domes of the Coastal Plain.

His success in his chosen field was due to the fact that he was a hard and conscientious worker. His determination and perseverence enabled him to overcome many obstacles and difficulties attending his work in the little known territory in which he worked. His acquaintances and friends were numerous, as he possessed a lovable and genial personality. Optimism and good humor permeated his being, and he was a sincere friend.

He was a member of The American Association of Petroleum Geologists, and an associate member of Sigma Xi, University of Chicago Chapter. He was a Mason.

On April 10, 1922, he married Miss Katharine Carroll, of Beaumont, Texas. He is survived by his wife, Katharine Phillips; a son, Carroll Douglas, aged 5; and a daughter, Alice, aged 3, all of Beaumont, Texas; his mother, Mrs. C. W. Phillips, who resides in Pineville, Louisiana; a brother, J. K. Phillips, of Alexandria, Louisiana; and a sister, Mrs. C. L. Clark, of Pollock, Louisiana.

FRITH C. OWENS

LAREDO, TEXAS
January 12, 1932

JOHAN AUGUST UDDEN

Johan August Udden was born at Lekasa, Sweden, March 19, 1859. Two years later he came to America with his parents, Andrew Larsen and Inga Lena (Andersdotter) Udden. His early youth was spent in Minnesota, where his parents had settled. He graduated from Augustana College, Rock Island, Illinois, in 1881 and married Johanna Kristina Davis in 1882. He was a student at the University of Minnesota in 1886 and received the degree of Master of Arts from Augustana College in 1889. From 1881 to 1888 he taught natural science and civics at Bethany College, Lindsborg, Kansas, and from 1888 to 1911 was professor of natural history and geology at Augustana College. Although giving temporary service in 1903-1904, his permanent connection with The University of Texas began in 1911 and continued until his death, January 5, 1932.

Dr. Udden was connected with several geological survey organizations. He was special assistant to the Iowa Geological Survey, working chiefly during the summer months, in the years 1897-1903; geologist of The University of Texas Mineral Survey, 1903-1904; geologist of the Illinois Geological Survey, 1906-1911; special agent of the United States Geological Survey, 1908-1914. He became geologist in the Bureau of Economic Geology and Technology of The University of Texas in 1911 and director in 1915.

Dr. Udden received four honorary degrees as follows: Doctor of Philosophy, Augustana College, 1900; Doctor of Science, Bethany College, 1921; Doctor of Science, Texas Christian University, 1923; and Doctor of Laws, Augustana College, 1929. An indication of his modest and quiet nature is seen in the fact that not one of his immediate associates, so far as the writer has been able to learn, knew, during his life, of this last honor received from Augustana College.

Dr. Udden held membership in several scientific societies, including the American Association for the Advancement of Science, Geological Society of America (Fellow, 1906), Society of Mining and Metallurgical Engineers, Sigma Xi, and the Illinois, Iowa, Oklahoma, and Texas academies of science. In 1929 he was elected honorary member of the Society of Economic Paleontologists and Mineralogists. His field of investigation included stratigraphic and areal

geology, work of the atmosphere, till in the Upper Mississippi Valley, clastic sediments, and related subjects. His published papers on these subjects number about 100 titles. In recognition of his distinguished service to science, he was knighted in 1911 by the King of Sweden.

Of his long and varied services on geological surveys only a limited account can be given here. From the standpoint of the immediate interests of The University of Texas, his greatest accomplishment was perhaps to infer that underlying the seemingly very flat and featureless Permian basin of Texas there possibly were structural features favorable to the accumulation of oil and gas in commercial quantities. This inference grew out of his observation in Trans-Pecos Texas and was expressed to the Regents in his report on University lands made in 1916. Another inference that may ultimately mean much to the University was that potash salts were likely to be found in this same Permian basin. This inference was correct, as was proved in 1913 as a result of the drilling of a well on the S. M. Swenson ranch in the vicinity of Spur, Texas. Potash minerals were found in the cuttings and the presence of potash proved by analyses of samples of water taken from this well. He was probably the first in this country to foresee the useful application of geophysical instruments in making underground observations, and published a paper on this subject in 1920.

Perhaps Dr. Udden's most notable contribution to methods of geologic work was his development in this country of the minute study of the sedimentary rocks and the identification of formations by such studies, followed naturally by closer attention to the microscopic fossils. This method of study initiated in this country by him has now become widespread. It is not necessary at this time to list the large series of publications issued by Dr. Udden. Among these, his study of the great Permian section of the Glass Mountains region will always stand out as a notable contribution to the geology of the Southwest.

Greater than his accomplishments as a scientist were his outstanding characteristics as a man and a friend. His sturdy individuality and independence of thought were accompanied by a profound respect for the opinion of others. He was helpful to the fullest extent to his associates and patient in listening to and understanding the problems of those who came to him for help. During his long term of service no one who applied to him was denied his most careful consideration and the benefit of a matured opinion freely given.

A full life was given to the service of science, seven years at Bethany College, twenty-three years at Augustana College, and twenty-one years in Texas. During this time he initiated important new methods of investigation, recorded new observations valuable to many industries, promoted the development of resources of great value to the state and nation, and gave advice to thousands who consulted him. The world has been greatly enriched by his life.

E. H. SELLARDS

AUSTIN, TEXAS
February 10, 1932

SALVADOR ORTIZ DAVILA

On December 1, 1931, there died in Guadalajara, Mexico, a geologist and engineer of whom The American Association of Petroleum Geologists may well be proud.

Salvador Ortiz Davila was born April 11, 1902, in Guadalajara. His father was Miguel Ortiz Gordoa, now deceased, his mother Hermina Davila de Ortiz.

Davila attended grammar school in Guadalajara and took his college preparatory work at St. Mary's, Berkeley, California, in 1915-1919. In 1919 he entered the Colorado School of Mines, from which institution he received the degree of E. M. in 1923.

He was employed as junior geologist by the Agwi Petroleum Company, Tampico, Mexico, in the summer of 1922. In September, 1924, he accepted the position of assistant geologist with the Compania Petrolio del Aguila, and was sent to Puerto Mexico on the Isthmus of Tehuantepec, where he remained until the following July. In August, 1925, he entered the petroleum engineering department of the Huasteca Petroleum Company, at Tampico, and in the following year was transferred to the geological department, where he served as geologist until June, 1931. He became an active member of The American Association of Petroleum Geologists on September 10, 1929.

On October 31, 1931, he married Miss Doris Carstens Orosco. He died of typhoid fever one month later.

He is survived by his mother, Hermina Davila de Ortiz, his wife, Doris Carstens de Ortiz, and three brothers and four sisters.

Salvador Ortiz Davila won the friendship of all who knew him. He was a tall, athletic, handsome man, quiet in manner and absolutely fearless. Born a gentleman, he inspired respect wherever he went. He had travelled extensively in the United States and knew his own country thoroughly, including the wild peninsula of Lower California. He had worked in Nicaragua and travelled through much of Central America.

Among his comrades in many adventures his name will never be forgotten.

CARROLL H. WEGEMANN

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 16, NO. 3 (MARCH, 1932), PP. 331-334

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

The drilling of the deepest well in the United States is described in an article "OklahomaWell Sets Depth Record for United States," by Floyd Swindell, in the January 29, 1932, issue of *The Oil Weekly*.

GAGE LUND, petroleum engineer for the California Company in the East Texas field, and Miss Mary Frances Lamar of Dallas, Texas, were married at San Antonio, January 23. They will make their home at Tyler, Texas.

HUGH MCCLELLAN, formerly with the Burke-Greis Oil Company, at Tulsa, has moved to Hutchinson, Kansas, for the practice of consulting geology.

RICHARD C. KERR, of the Continental Air Map Company, Los Angeles, California, has an article entitled "Mapping Rights of Way from the Air" in the January, 1932, issue of *Petroleum World*.

ARNALDO BELLUIGI, geophysicist for Azienda Generale Italiana Petroli (A. G. I. P.), has an article in the January, 1932, issue of *World Petroleum*, entitled "Geophysical Studies in Italy."

K. C. SCLATER, Oil and Gas Production Editor of *The Petroleum Engineer*, has an article in the January, 1932, issue of that publication, entitled "Water Encroachment Control Sound Economical Practice."

GEORGE R. PINKLEY, consulting geologist, formerly chief geologist for the Sneed Royalty Company of Tulsa, is now located in San Antonio, Texas.

WALLACE H. COLLINS, Shell Petroleum Corporation, Tulsa, has gone to The Hague, Holland, for training and instruction in the technical department of the Dutch Shell Oil Company there.

PEYTON M. BIRDSONG, formerly manager of the geological and engineering department of the World Oil Company, and J. D. FREEMAN, formerly connected with the Southern Crude Oil Engineering department, have formed the Birdsong-Freeman Company, office and field engineering, with headquarters at Fort Worth, Texas.

HENRY C. CORTES, formerly with the Vacuum Oil Company, Houston, is now doing geological and geophysical work for the Magnolia Petroleum Company in Texas and Louisiana. His address is Box 872, Lake Charles, Louisiana.

R. B. WHITEHEAD, chief geologist for the Atlantic Oil Producing Company, Dallas, Texas, addressed the Tulsa Geological Society, Monday, February 1, on "A Review of the East Texas Oil Field, with Notes on Estimated Future Recovery."

H. E. ZOLLER, district petroleum engineer in East Texas for the Shell Petroleum Corporation, has left for The Hague, Holland, where he will spend six months at the Shell's training school.

HERBERT C. G. VINCENT has resigned from the Royal-Dutch Shell Company, and will take up independent geological and chemical work in Europe.

MAX W. BALL, consulting petroleum engineer, Denver, Colorado, gave an address on "The Future of the Oil Producing Industry," before the Joint Annual Meeting of the Colorado Mining Association and the Colorado Chapter of the American Mining Congress, Colorado Springs, January 15, 1932.

E. D. LUMAN, chief geologist for the Atlantic Oil Producing Company, Tulsa, presented a paper before the Tulsa Geological Society, January 19, on "Wapanucka Limestone of Southeast Oklahoma." He addressed the Shawnee Geological Society at their regular monthly meeting, January 25, on the same subject.

GUY E. GREEN, formerly with the Vacuum Oil Company, San Angelo, Texas, may be addressed at 2110 Alamo National Building, Magnolia Petroleum Company, San Antonio, Texas.

E. DEGOLYER, 165 Broadway, New York City, has been appointed the Association representative to confer with the committees of the International Scientific Expedition to the West Indies. RICHARD M. FIELD, department of geology, Princeton University, is director of the expedition.

EDGAR F. BULLARD is vice-president of the Stanolind Oil and Gas Company at Tulsa, Oklahoma.

E. H. SELLARDS, Austin, Texas, who has been acting director of the University of Texas bureau of economic geology, has been named director of the bureau by the university board of regents.

IRA H. CRAM, paleontologist and assistant geologist of the southwestern division of The Pure Oil Company, has been made chief divisional geologist, succeeding A. A. LANGWORTHY, resigned.

A. E. FATH is back in the United States after a two years' investigation of oil possibilities in Germany. His address is Room 2112, 41 Trinity Place, New York City.

CHESTER W. WASHBURNE, 149 Broadway, New York City, planned to leave early in February on a long professional trip to several districts.

SILAS L. GILLAN, geologist, of Los Angeles, has gone on an extended world cruise.

CHESTER NARAMORE, general manager of the North European Oil Corporation, Hanover, Germany, is spending some time in the United States.

FRANK STANGL, JR., geologist with the Stanolind Oil and Gas Company, has been transferred from San Angelo to San Antonio, Texas.

GERALD A. WARING, of Tulsa, Oklahoma, has returned to Alaska for the United States Geological Survey in connection with core drilling to be done in the Anthracite Ridge coal basin, about 150 miles inland from Seward in south-central Alaska. The work will extend through a period of six months.

Northwest Oil and Gas World (Seattle, Washington) for February contains an article on "Petroleum Geology and Its Application in Southwest Washington," by William T. Nightingale, geologist for the Ohio Oil Company, as delivered before the fifth annual Mining Institute of the University of Washington, January 19, 1932.

A. W. LAUER, chief geologist for The Texas Company at Tulsa, presented a paper on "Criteria for Petroleum Provinces" before the Tulsa Geological Society on February 15.

C. H. BEHRE, Jr., and W. H. BUCHER, professors of geology at Northwestern University and the University of Cincinnati, respectively, gave exchange lectures at the two universities last January.

CHARLES T. LUPTON, consulting geologist of Denver, Colorado, has been working in central Washington.

DEAN E. WINCHESTER, consulting geologist of Denver, Colorado, is mapping the geology of the oil fields of New Mexico.

The Shreveport Geological Society, Shreveport, Louisiana, presented the following program on February 5: H. W. BELL, consulting engineer for the Lion Oil Refining Company, El Dorado, Arkansas, spoke on "The Deep Test of the Lion Oil Refining Company at Smackover"; C. P. DUNBAR, paleontologist for the Minerals Division of the Louisiana Conservation Commission, Shreveport, spoke on "General Notes on West Indian Geology"; and F. J. MILLER, geologist with the Arkansas Natural Gas Corporation, Shreveport, spoke on "Gas and Oil Resources of Western Kansas."

F. PARK GEYER, former vice-president of the Marland Oil Company of Texas, died, February 7, 1932.

The Shreveport Geological Society, of which WILLIAM F. CHISHOLM is president and GEORGE W. SCHNEIDER is secretary-treasurer, is planning its annual field trip for next June in southeastern Mississippi and southwestern Alabama.

PAUL M. BUTTERMORE, formerly with the Mid-Kansas Oil and Gas Company at Fort Worth, may be addressed at 3105 Odessa Street, Fort Worth, Texas.

The associates of Dr. Johan August Udden in the Bureau of Economic Geology of The University of Texas, after consulting with many of his friends, are undertaking to establish a publication and research fund in his honor. Twenty-one years of his life were thus given in the service of the State of Texas. During this time he initiated important new methods of investigation, recorded new observations valuable to many industries, promoted the development of

resources of great value to the State, and gave advice to thousands who consulted him. It seems appropriate that the work that he initiated be continued by establishing in his name a publication and research fund. It is hoped that as many of his friends as may wish to do so will contribute to this fund. Contributions may be made of any amount and may be addressed to the Bureau or to the Auditor of the University at Austin. All contributions received will be transmitted to the Regents of the University to form a part of this fund recorded under the name of the contributor. The Bureau staff will appreciate an expression with or without contribution from those who wish to be recorded as interested in and endorsing this worthy undertaking.

The price of the cloth-bound volume of the Bulletin for 1931 (Vol. 15) has been reduced from $5.00 to $4.00 for members and associates not in arrears, if purchased before April 1 (only one copy per member or associate). After April 1, the special member price is $7.00.

O. L. BRACE, geologist for E. L. Smith Oil Company, Tyler, Texas, has an article, "East Texas Well Cores Tell Story" in the *Oil and Gas Journal* for February 18.

DORSEY HAGER, consulting geologist, may be addressed at the Hotel Morck, Aberdeen, Washington.

E. E. ROSAIRE and F. M. KANNENSTINE, having severed their connections with the Geophysical Research Corporation, are planning to become associated as Rosaire and Kannenstine, consulting geophysicists, with offices in the Esperson Building, Houston, Texas.

J. J. GALLOWAY of the University of Indiana, has given a series of lectures at Columbia University.

DANA M. SECOR, consulting geologist, is studying geophysics at Columbia University.

N. C. DAVIES is with the Penn York Natural Gas Corporation at Elmira, N. Y.

J. FRENCH ROBINSON, of Wellsboro, Pennsylvania, is vice-president and general manager of the Lycoming Natural Gas Company.

LAWRENCE P. SPENCER, consulting geologist, has headquarters at the Hotel Von Stuben, Corning, New York.

F. S. LOTT, of Brokaw, Dixon, Garner, and McKee, is stationed at Elmira, New York.

D. T. RING is chief geologist for the Columbia Gas and Electric Company interests at Columbus, Ohio.

R. E. GRIM is sedimentary petrographer for the Illinois State Geological Survey.

FRED WILCOX has moved from Midland, Texas, to Wellsboro, Pennsylvania.